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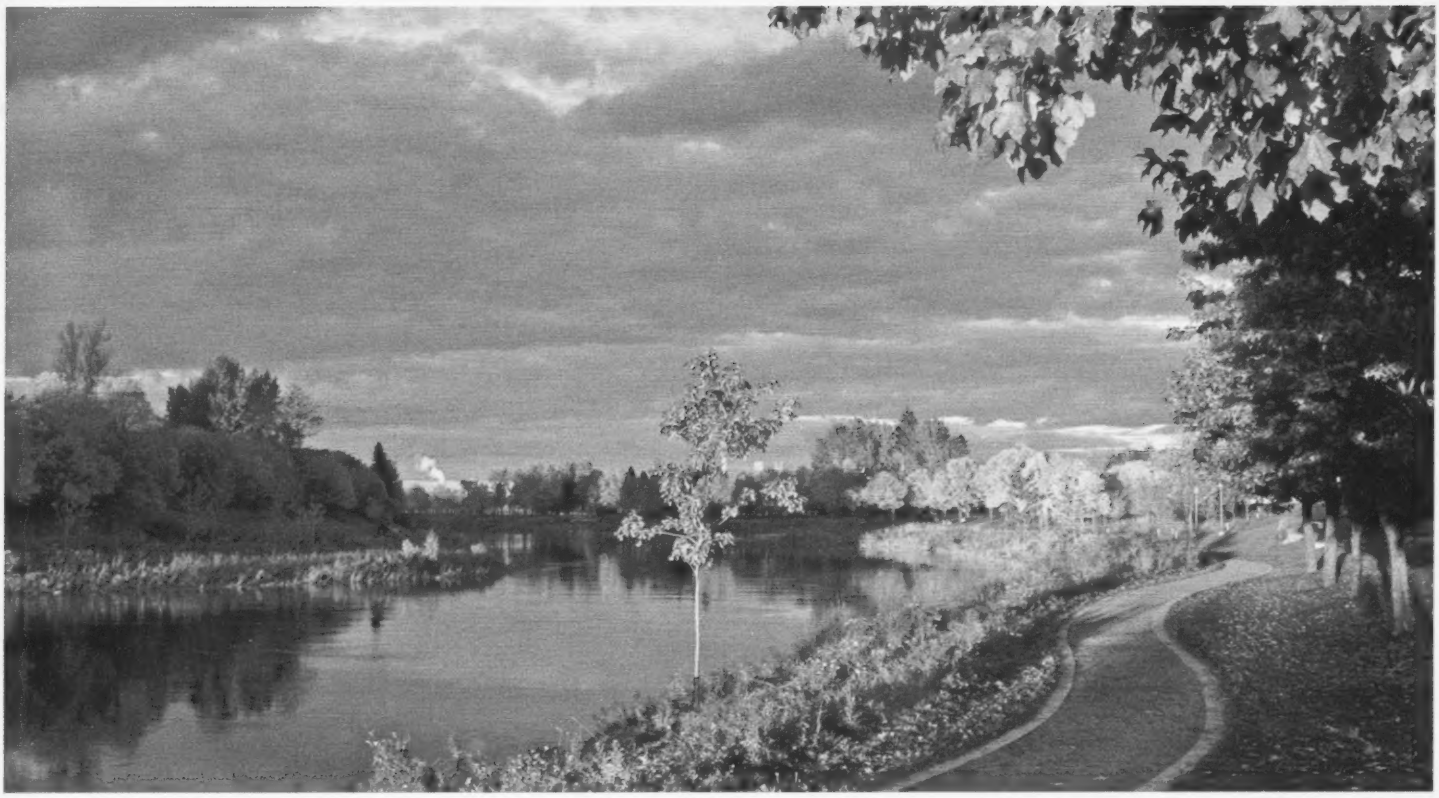
Centre - Eau Terre Environnement

Annual Report 2011-2012



Annual Report from 1 May 2011 to 30 April 2012

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I am pleased to present the 11th annual report of the Centre Eau Terre Environnement of the Institut national de la recherche scientifique for the year 2011-2012.

The mission of the Centre is to contribute to sustainable development and environmental protection, particularly in the fields of water and earth sciences. Graduate training, diffusion of knowledge, and technology transfer are all essential elements of this mission, and these activities have led to numerous achievements during the year.

This report features the main research projects of the year in the different specialty fields of the Centre. Examples include projects on adapting water resource management to climate change in Canada and Western Africa, reducing metal contamination risks for aquatic ecosystems, characterizing groundwater in the Chaudière-Appalaches region, and extracting lipids from wastewater sludge to produce biodiesel; all of these projects originated in ideas and initiatives of the Centre's dynamic group of researchers.

Professors at the Centre have had notable successes this year in financing research. Two research chairs have had their financing renewed, the chair on bioconversion of wastewater and sewage sludge into high-value-added products and that on biogeochemistry of trace elements. Four new NSERC Engage Grants have been obtained, fostering the development of new partnerships with companies.

At the INRS fall convocation ceremony, 8 PhD students and 18 Master's students in water and earth sciences received a diploma. In addition, five students completed the professional Master's program in water sciences.

In November, a book commemorating 30 years of geoscience research at the INRS was published as part of the celebration of the 10th anniversary of the Centre Eau Terre Environnement, which was created in 2001 by merging the INRS-Eau and Géoressources centres. A companion volume, a history of water research at the INRS, was published in 2009.

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The present report highlights the main achievements of the Centre Eau Terre Environnement during 2011-2012. Credit for these successes belongs to the entire community, including professors, students, research and administration personnel, associate researchers, in particular those of the Geological Survey of Canada with whom we share our offices, and all of the support staff.

I sincerely thank them all and encourage them to pursue their excellent work in the future.

The Director,
Yves Bégin

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Centre Eau Terre Environnement

Institut national de la recherche scientifique (INRS)

The mission of INRS (Quebec's national institute of scientific research) is to conduct pure and applied research for the cultural, economic, and social benefit of Quebec. This university research institution seeks to train highly qualified professionals at the graduate level and ensure the transfer of knowledge and technologies in its areas of expertise. INRS offers to its students and professors an innovative research environment focused on society's needs.

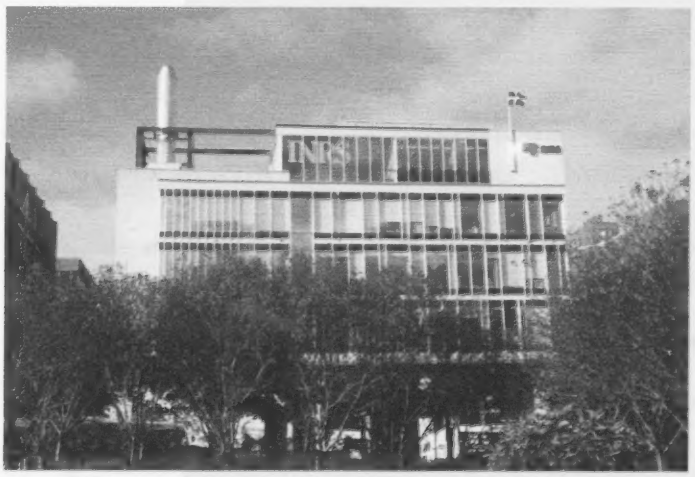
INRS is composed of four research centres:

- Eau Terre Environnement
  (water, earth, and the environment)
- Énergie Matériaux Télécommunications
  (energy, materials, and telecommunications)
- INRS–Institut Armand-Frappier (health)
- Urbanisation Culture Société
  (urbanization, culture, and society)

The Centre is actively engaged in the sustainable development of Quebec, particularly in the fields of water science, georesources, and the environment. Its research is at the forefront of scientific and technological advances, facilitating the protection and sustainable development of natural resources. The Centre offers graduate programs (PhD, research and professional Master's) in water and earth sciences. Internships are also available at all university levels.

The scientific program is divided into four main research fields: hydrology, environmental decontamination and waste reclamation, aquatic biogeochemistry and contamination issues, and geological sciences.

The Centre is located in downtown Québec City within the urban campus of the Université du Québec. Its large-scale laboratories are located at the Metropolitan Québec Technology Park, and it has a field research station in the Saguenay region.



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Centre - Eau Terre Environnement

Hydrology 2011-2012

Canada possesses about 9% of the world's renewable water supply

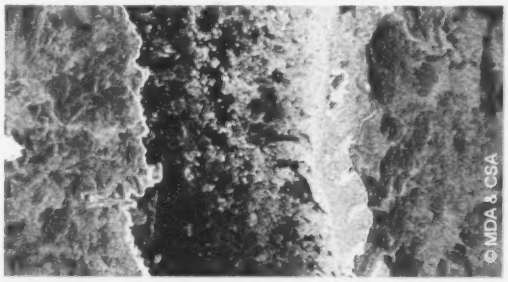
Sustainable management of this vital resource is a priority research subject at the Centre Eau Terre Environnement, which hosts the most important group of university experts in water research in Canada.

The Centre's expertise derives from its long experience in developing and applying numerical approaches to analysis and decision-making in a range of water management contexts. The group's multidisciplinary skills enable thorough analysis of resource availability and associated environmental problems. Graduate training, diffusion of knowledge, and technology transfer are all important components of the Centre's mission.

Examples of research applied to current challenges

Ice monitoring, a northern concern

Researchers from five northern countries are working on methods to monitor ice cover in rivers and lakes through the NorthHydrology consortium. The objective of the research is to improve monitoring tools based on satellite images and integrate their by-products (maps, statistics) into hydrological or climatic prediction models. The INRS team focuses on optimizing a tool used to monitor river ice dynamics (IceMap-R) using high-resolution satellite radar images in order to integrate this tool into ice jam and flood forecasting systems.



Overflows in sight?

Scenarios for the future climate of southern Quebec predict that before 2050 there will be an increase in precipitation and a higher frequency of heavy rains. This will likely affect the performance of urban rainwater drainage systems. The potential impacts (overflows, floods) could be costly. Researchers are carrying out hydrological simulations of five urban drainage networks in order to evaluate their performance in future climates. Different adaptation strategies to climate change will be compared, and the results will be used to guide the efforts of municipalities to maintain the performance level of their drainage networks over the long term.

Modeling fluvial dynamics

The St. Lawrence fluvial estuary stretches more than 160 km from the eastern tip of Lake Saint-Pierre to the eastern end of Ile d'Orléans. Researchers are building a 2D numerical advection–diffusion model to predict water quality in this section of the river in real time and in the future. The water quality of the St. Lawrence is subject to spatial and temporal variations influenced by many natural and anthropogenic factors. An airborne LIDAR (remote sensing using laser) survey will enable collection of high-resolution data on riverbanks, intertidal zones, and shoals between Montmagny and Trois-Rivières. These data will then be entered into a hydrodynamic model of the St. Lawrence fluvial estuary.

Main study themes and researchers involved

WATERSHED HYDROLOGY

Development of hydrological modeling and decision-making software to assist in integrated watershed management. | Development of remote sensing and geomatics tools for the evaluation and monitoring of water resources.

Monique Bernier | Remote sensing | monique.bernier@ete.inrs.ca
Karem Chokmani | Remote sensing | karem.chokmani@ete.inrs.ca
Alain N. Rousseau | Modeling | alain.rousseau@ete.inrs.ca
Jean-Pierre Villeneuve | Integrated management
jean-pierre.villeneuve@ete.inrs.ca

URBAN HYDROLOGY

Diagnosis of the structural condition of aqueduct and sewer networks and estimation of the optimal time to repair or replace them. | Control of contamination caused by sewer overflows. | Assessment of the vulnerability of drinking water supplies to climate change.

Sophie Duchesne | Infrastructure | sophie.duchesne@ete.inrs.ca
Alain Mailhot | Modeling and management | alain.mailhot@ete.inrs.ca
Jean-Pierre Villeneuve | Integrated management

ENVIRONMENTAL HYDRAULICS

Development of numerical simulation models for large-scale river hydrodynamics and water quality studies. | Characterization of rivers, modeling of fish habitats, and study of the impacts of anthropogenic disturbance on fish habitats.

Normand Bergeron | Fluvial geomorphology and habitat
normand.bergeron@ete.inrs.ca
Yves Secretan | Numerical hydrology | yves.secretan@ete.inrs.ca

STATISTICAL HYDROLOGY

Modeling and estimation of hydrological variables and extreme events in relation to climate change. | Statistical analysis of water resources and measurement networks. | Application of statistical environmental hydrology to characterization and management of aquatic habitats.

Fateh Chebana | Modeling | fateh.chebana@ete.inrs.ca
Taha B.M.J. Ouarda | Hydrometeorology | taha.ouarda@ete.inrs.ca
André St-Hilaire | Environmental hydrology
andre.st-hilaire@ete.inrs.ca

Examples of recent publications

(Centre ETE authors are in **bold**)

- **Ben Aissia, M. A.**, **Chebana, F.**, **Ouarda, T. B. M. J.**, Roy, L., Desrochers, G., Chartier, I. & Robichaud, É. (2012). Multivariate analysis of flood characteristics in a climate change context of the watershed of the Baskatong reservoir, Province of Quebec, Canada. *Hydrological Processes*, 26 (1): 130-142.
DOI: 10.1002/hyp.8117

- **Bergeron, N. E.**, Buffin-Bélanger, T. B. & Dubé, J. (2011). Conceptual model of river ice types and dynamics along sedimentary links. *River Research and Applications*, 27 (9): 1159-1167.
DOI: 10.1002/rra.1479

- **Beveridge, D.**, **St-Hilaire, A.**, **Ouarda, T. B. M. J.**, **Khalil, B.**, Conly, F. M., Wassenaar, L. I. & Ritson-Bennett, E. (2012). A geostatistical approach to optimize water quality monitoring networks in large lakes: Application to Lake Winnipeg. *Journal of Great Lakes Research*, 38 (Supplement 3): 174-182.
DOI: 10.1016/j.jglr.2012.01.004

- **Bouda, M.**, **Rousseau, A. N.**, Konan, B, **Gagnon, P.** & Gumiere, S. J. (2011). Case study: Bayesian uncertainty analysis of the distributed hydrological model HYDROTEL. *Journal of Hydrologic Engineering*, 17 (9): 1021-1032.
DOI: 10.1061/(ASCE)HE.1943-5584.0000550

- **Khaldoune, J.**, Van Bochove, E., **Bernier, M.** & Nolin, M. C. (2011). Mapping agricultural frozen soil on the watershed scale using remote sensing data. *Applied and Environmental Soil Science*, 193237: 1-16.
DOI: 10.1155/2011/193237

- Holanda, P. S., Blanco, C. J. C., Cruz, D. O. A., Lopez, D. F., Baganha Barp, A. R. & **Secretan, Y.** (2011). Hydrodynamic modeling and morphological analysis of Lake Água Preta: One of the water sources of Belém-PA-Brazil. *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, 33 (2): 117-124.
DOI: 10.1590/S1678-58782011000200001

- **Mailhot, A.**, **Beauregard, I.**, **Talbot, G.**, Caya, D. & Biner, S. (2012). Future changes in intense precipitation over Canada assessed from multi-model NARCCAP ensemble simulations. *International Journal of Climatology*, 32 (8): 1151-1163.
DOI: 10.1002/joc.2343

- **St-Hilaire, A.**, **Ouarda, T. B. M. J.**, Bargaoui, Z., **Daigle, A.** & Bilodeau, L. (2012). Daily river water temperature forecast model with a *k*-nearest neighbour approach. *Hydrological Processes*, 26 (9): 1302-1310.
DOI: 10.1002/hyp.8216

Some research partners

- Canadian and European space agencies
- Conseil de gestion du bassin-versant de la rivière Restigouche
- Government of Canada (Agriculture and Agri-Food; Environment)
- Government of Quebec (Agriculture, Fisheries and Food; Health and Social Services; Hydrological Expertise Centre; International Relations; Public Safety; Transport)
- Institut de recherche et de développement en agroenvironnement (IRDA)
- International Development Research Centre (IDRC)
- Ouranos Consortium on Regional Climatology and Adaptation to Climate Change
- Québec City

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Centre - Eau Terre Environnement

Decontamination & reclamation 2011-2012

In Quebec, 25 tonnes of non-toxic waste are produced every minute; this waste has great potential for recycling and reuse

Cities and industries face major challenges with respect to waste recycling and reuse, and thus improved methods and technologies are constantly being sought.

The Centre Eau Terre Environnement is a leader in the development of environmental technologies. Its researchers possess unique expertise in the development of treatment and reclamation technologies of contaminated sewage sludge, effluents, and solid waste. Moreover, the Centre has one of the most complete and flexible pools of pilot equipment and analytical instruments in Canada for research and development projects. New technologies conceived at the Centre are regularly patented and transferred to industry. Graduate training is also an important component of the mission.

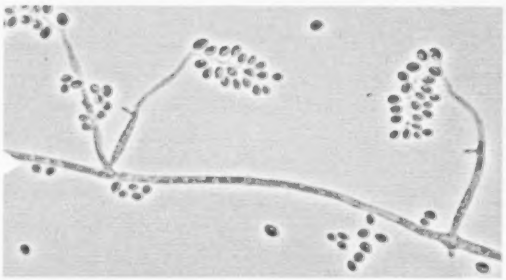
Examples of research applied to current challenges

No further pollution allowed

Acid mine drainage is a major environmental issue. An increasingly common method to reduce environmental contamination caused by metal-laden mine wastewater is to install sulphate-reducing biofilters composed of natural materials (wood bark and chips, peat, limestone, etc.). However, at the end of the filtering process these contaminated biomasses have to be dealt with. Researchers are examining the biogeochemical behaviour of these materials with the objective of developing new technological avenues to dispose of or recycle them safely and economically.

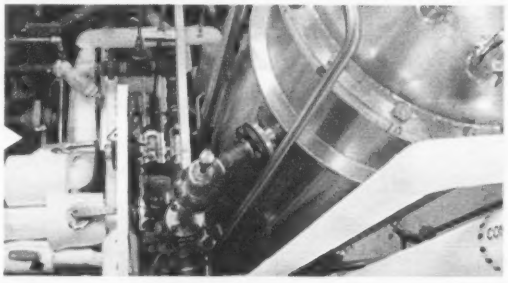
Yeast-fed productive microbes

Biopesticides constitute an ecological alternative to chemicals in the fight against insect pests in agriculture and forestry. Biopesticides are produced by microbial fermentation in a culture medium. Microbial growth and activity is strongly affected by the quantity and quality of the nutrients provided to the microbial culture. Yeast extracts are one example of such ingredients. Different types of yeast extracts are being tested to select those that enhance biopesticide yield the most.



Clean fuel derived from wastewater

The demand for biofuel is increasing. Biodiesel is obtained by converting vegetable oil or animal fats using a chemical process called transesterification. A group of researchers focusing on obtaining value-added products from sewage sludge has isolated new microbial strands that accumulate a large quantity of lipids, which can be converted into biodiesel. Researchers are working to optimize the extraction and transesterification processes. The goal is two-fold: reduce the quantity of sewage sludge that needs to be eliminated and reduce our dependence on petroleum.



Main study themes and researchers involved

ENVIRONMENTAL DECONTAMINATION

Development and optimization of processes used to remove toxic metals and organic contaminants from solid matrices. | Development of treatment technologies for industrial and urban wastewater and sewage sludge.

Jean-François Blais | Decontamination
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Patrick Drogui | Electrotechnologies
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Guy Mercier | Decontamination and reclamation
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Normand Tassé | Geochemistry
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WASTE AND BIOMASS RECLAMATION

Development of transformation, bioconversion, or recycling processes for different types of urban and industrial waste. | Development of biotechnologies to convert sewage sludge into value-added products.

Mario Bergeron | Inorganic and environmental chemistry
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Satinder Kaur Brar | Bioconversion and emerging contaminants
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Rajeshwar Dayal Tyagi | Waste bioconversion
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Examples of recent publications

(Centre ETE authors are in **bold**)

- **Bisone, S.**, **Blais, J.-F.**, **Drogui, P.** & **Mercier, G.** (2012). Toxic metal removal from polluted soil by acid extraction. *Water, Air & Soil Pollution*, 223 (7): 3739-3755. DOI: 10.1007/s11270-012-1145-1

- **Dhillon, G. S.**, **Brar, S. K.**, Kaur, S. & Verma, M. (2012). Green approach for nanoparticle biosynthesis by fungi: Current trends and applications. *Critical Reviews in Biotechnology*, 32 (1): 49-73. DOI: 10.3109/07388551.2010.550568

- **Gnepe, J. R.**, **Tyagi, R. D.**, **Brar, S. K.**, Valéro, J. & Surampalli, R. Y. (2012). Pre-treatment of agro-industrial waste used as alternative nutrients for rearing *Cydia pomonella*. *Biosystems Engineering*, 111 (3): 261-270. DOI: 10.1016/j.biosystemseng.2011.12.002

- **Mercier, G.**, **Blais, J.-F.**, **Dhenain, A.** & **Chartier, M.** (2011). Improvement of a three-step process for the treatment of aluminium hazardous wastes containing PAHs (benzo[b,j,k]fluoranthene and chrysene) and fluoride. *Environmental Technology*, 32 (16): 1883-1893. DOI: 10.1080/09593330.2011.567302

- **Zaviska, F.**, **Drogui, P.**, **Blais, J.-F.** & **Mercier, G.** (2012). Electrochemical treatment of bisphenol-A using response surface methodology. *Journal of Applied Electrochemistry*, 42 (2): 95-109. DOI: 10.1007/s10800-011-0376-y

Some research partners

- Centre technologique des résidus industriels (CTRI)
- Consortium de recherche et innovation en bioprocédés industriels au Québec (CRIBIQ)
- Government of Quebec (Agriculture, Fisheries and Food; International Relations)
- Hydro-Québec
- Société de protection des forêts contre les insectes et maladies (SOPFIM)
- Tecosol

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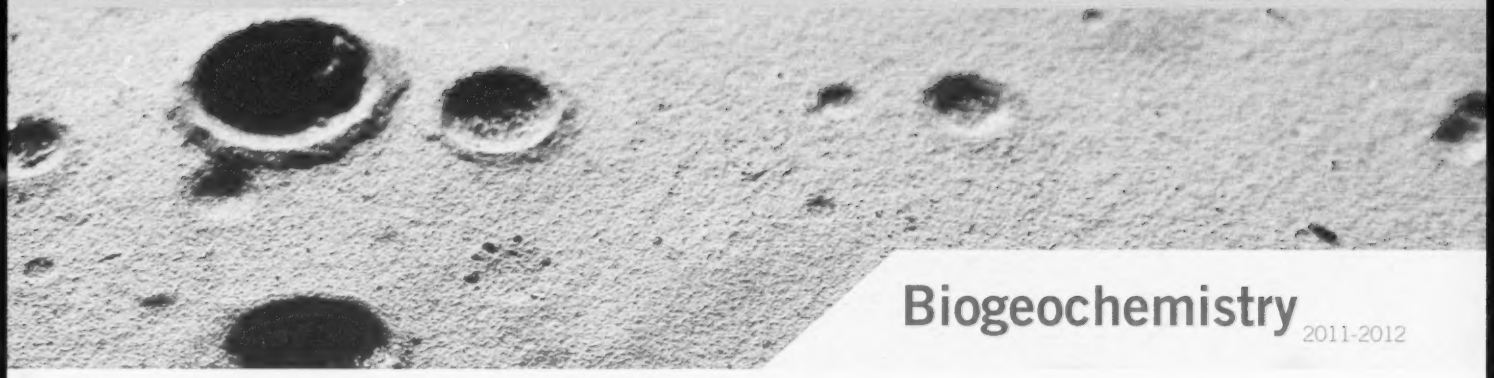


Biogeochemistry 2011-2012

Water pollution is the #1 environmental issue in Canada according to a recent survey

Pollutants entering aquatic ecosystems accumulate in sediments and concentrate up the food chain. A good knowledge of the processes controlling the exchange of toxic substances between sediments, the water column, and aquatic organisms, and of the effects of these substances on ecosystems, is essential in order to remediate the problem.

The Centre Eau Terre Environnement biogeochemistry research group makes a unique contribution to remediation efforts through its capacity to combine research on the dispersion of contaminants in the environment, the assimilation by aquatic organisms of trace metals and their effects on the organisms, and the detection of environmental changes in aquatic ecosystems by using certain organisms as sentinels. Graduate training, diffusion of knowledge, and technology transfer are all important components of the Centre's mission.

Examples of research applied to current challenges

Eating fish is not always good for you

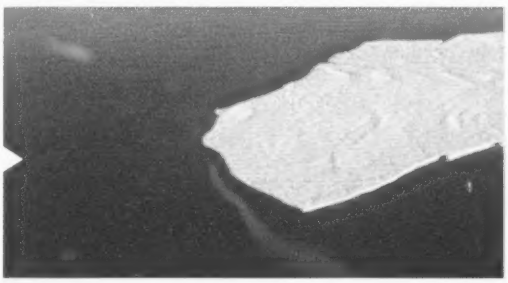
High mercury concentrations in fish cause toxic effects in the fish themselves and are detrimental to consumers' health. Landlocked Arctic char, a popular species of fish in northern Canada, is often contaminated; about 30% of the populations exceed toxicity thresholds for mercury in fish. Sampling of char in several lakes that span a gradient of mercury contamination on Cornwallis Island in the Canadian Arctic is planned. The objective is to determine toxicity thresholds for these fish and to examine the effects of mercury contamination on the anatomy and physiology of their liver, on their reproduction, and on their general health.

Using algae to detect problematic lakes

Diatoms (microscopic algae) are used to monitor aquatic ecosystems. The Eastern Canadian Diatom Index (IDEC) integrates different types of river degradation (mainly eutrophication), enabling identification of disturbed sites. Researchers are working on optimization of this index by among other things increasing the number and spatial distribution of samples. The first version of IDEC dates from 2006. Since then it has been used to evaluate water quality in more than 700 sites in Quebec and Ontario. The first use of the new version of IDEC will be to monitor rivers in Gatineau Park.

The polar ice is melting faster than expected

Ice cover in the Arctic, a prime indicator of climate change, reached a record low this year, well beyond that predicted by numerical models. In recent years, ice cover has systematically reached lower levels than those predicted by the models; this indicates that the parameters of these models need to be re-examined. One of the objectives of this project is to improve understanding of the physical processes controlling the circulation and mixing of water masses in the Arctic, including eddies, upwelling, and vertical convection during ice formation. Researchers are also interested in the water mass exchanges between Baffin Bay and the Beaufort Sea through the Northwest Passage.



Main study themes and researchers involved

ENVIRONMENTAL GEOCHEMISTRY

Identification of contaminant sources and study of atmospheric transport and sedimentation in oceans and lakes. | Examination of the transport and fate of organic contaminants in agricultural areas.

Charles Gobeil | Aquatic contamination
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Pierre Lafrance | Organic contaminants
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AQUATIC ECOTOXICOLOGY

Study of metal accumulation mechanisms and detection of their effects on organisms at all scales, from cells to communities. | Development of tools to evaluate risks associated with aquatic environment contamination for animal populations and biodiversity.

Peter G.C. Campbell | Metal contaminants
pgc.campbell@ete.inrs.ca

Patrice Couture | Impacts on fish
patrice.couture@ete.inrs.ca

Paul Drevnick | Mercury contamination
paul.drevnick@ete.inrs.ca

Claude Fortin | Metal contaminants
claude.fortin@ete.inrs.ca

Landis Hare | Impacts on invertebrates
landis.hare@ete.inrs.ca

LIMNOLOGY AND OCEANOGRAPHY

Study of the effects of climate change on water mixing and transparency, the impacts of permafrost melting on the carbon cycle, and their interactions with lake microbial productivity. | Examination of physical processes (circulation and mixing) and their impacts on biological production in the Arctic Ocean.

Isabelle Laurion | Limnology and bio-optics
isabelle.laurion@ete.inrs.ca

Yves Gratton | Physical oceanography
yves.gratton@ete.inrs.ca

Examples of recent publications

(Centre ETE authors are in **bold**)

- **Caron, E.**, **Lafrance, P.** & **Auclair, J.-C.** (2012). Temporal evolution of atrazine and metolachlor concentrations exported in runoff and subsurface water with vegetated filter strips. *Agronomy and Sustainable Development*, 32 (4): 935-943. DOI: 10.1007/s13593-012-0087-8

- **Drevnick, P. E.**, Engstrom, D. R., Driscoll, C. T., Swain, E. B., Balogh, S. J., Kamman, N. C., Long, D. T., Muir, D. G. C., Parsons, M. J., Rolfhus, K. R. & Rossmann, R. (2012). Spatial and temporal patterns of mercury accumulation in lacustrine sediments across the Laurentian Great Lakes region. *Environmental Pollution*, 161 (February 2012): 252-260. DOI: 10.1016/j.envpol.2011.05.025

- **Gauthier, C.**, **Campbell, P. G. C.** & **Couture, P.** (2011). Enzymatic correlates of energy status in wild yellow perch inhabiting clean and contaminated environments. *Environmental Toxicology and Chemistry*, 30 (9): 2148-2156. DOI: 10.1002/etc.609

- **Lavoie, M.**, **Le Faucheur, S.**, Boullemant, A., **Fortin, C.** & **Campbell, P. G. C.** (2012). The influence of pH on algal cell membrane permeability and its implications for the uptake of lipophilic metal complexes. *Journal of Phycology*, 48 (2): 293-302. DOI: 10.1111/j.1529-8817.2012.01126.x

- Macdonald, R. W. & **Gobeil, C.** (2011). Manganese sources and sinks in the Arctic Ocean with reference to periodic enrichments in basin sediments. *Aquatic Geochemistry*, Online. DOI: 110.1007/s10498-011-9149-9

- Tremblay, J. É, Bélanger, S., Barber, D. G., Asplin, M., Martin, J., Darnis, G., Fortier, L., **Gratton, Y.**, Link, H., Archambault, P., Sallon, A., Michel, C., Williams, W. J., Philippe, B. & Gosselin, M. (2011). Climate forcing multiplies biological productivity in the coastal Arctic Ocean. *Geophysical Research Letters*, 38 (18): L18604. DOI: 10.1029/2011GL048825

Some research partners

- ArcticNet
- Government of Canada (Aboriginal Affairs and Northern Development; Environment)
- Ontario Ministry of the Environment
- Ouranos Consortium on Regional Climatology and Adaptation to Climate Change
- Rio Tinto Alcan
- Vale Inco

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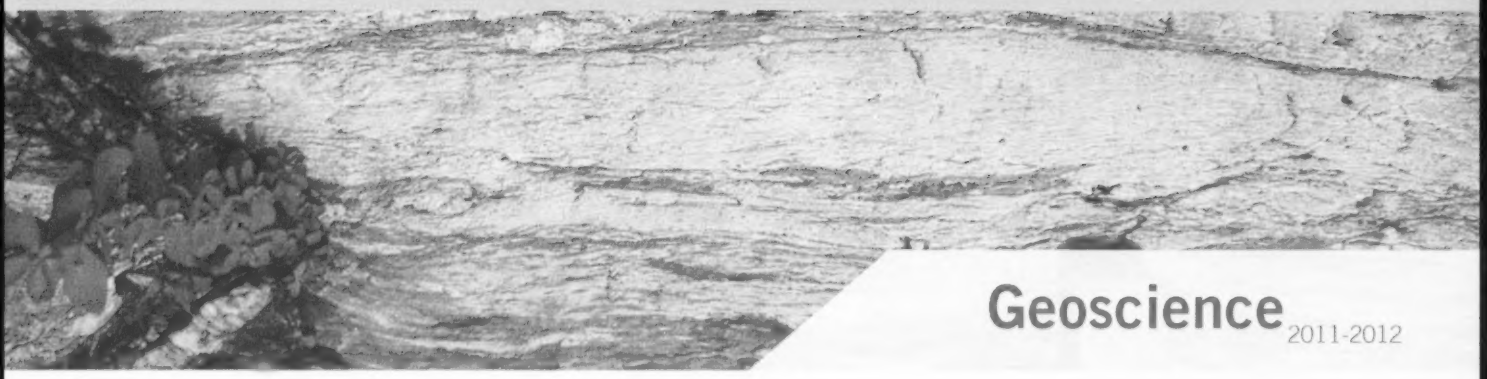


Geoscience 2011-2012

Shale gas, groundwater, mining, coastal erosion: Geoscientific issues are ubiquitous in the news in Quebec

The increasing demand for mineral, oil and gas resources, the need for sustainable management of groundwater resources, the risks posed by natural hazards related to geological processes, and the impacts of climate change are all crucial issues for researchers in geological sciences.

The Centre Eau Terre Environnement and the Quebec division of the Geological Survey of Canada work together under a scientific collaboration agreement between the INRS and Natural Resources Canada. This university–government partnership has created the most important multidisciplinary research group in geosciences in Canada, the Centre géoscientifique de Québec (CGQ). Graduate training and diffusion of knowledge are essential components of the CGQ's mission.

Examples of research applied to current challenges

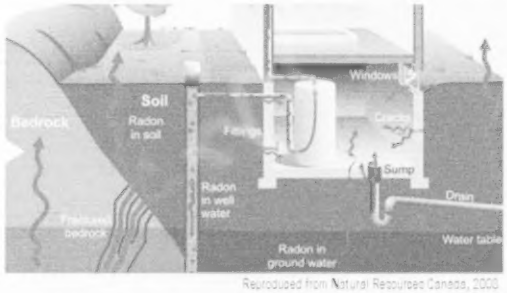
CO_2 storage in aquifers

Geological storage of CO_2 is one of the options being considered to reduce greenhouse gas emissions to the atmosphere. Deep saline aquifers are a type of reservoir that could be used to store CO_2 in Quebec. However, to make sure that this storage method is safe, the responses of these potential reservoirs to CO_2 injection must be assessed closely. Since saline aquifers are very deep, they are difficult to access using drilling methods. Thus, geophysical techniques provide the best characterization tools. These can be used to better understand the effects of CO_2 injection on the seismic and electrical responses of the aquifers.

Courtesy of Danilo Rizzuti / FreeDigitalPhotos.net

Radon in the home

Radon is a radioactive gas that poses health risks. Radon is released naturally by the ground, but it can become a problem when it infiltrates homes and accumulates inside. A project is currently underway in collaboration with the government of Quebec to use geoscientific indicators to predict the zones where homes are at greatest risk of elevated radon levels. A residential area for which all types of data are available (airborne and terrestrial radiometry measurements, geochemical and geological surveys) will be used to validate the correlations between geoscientific data and radon concentrations in homes.



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Volcanoes hiding diamonds

Maars are the second most common type of volcano. Their eruptions pose risks to people and infrastructure. Diatremes, which are debris-filled volcanic pipes, are found underneath maars. Kimberlitic diatremes may contain diamonds. Such diatremes have been found in Canada, which has become an important player in the world diamond industry. Little is known about maar–diatreme volcanic processes since they mostly occur underground. A combination of large-scale volcanologic experiments and studies of diatremes will enable researchers to better understand their volcanic processes and thus assess not only the risk of eruptions but also the potential economic value of these formations.

Main study themes and researchers involved

GEOPHYSICS AND ENVIRONMENTAL GEOLOGY

Modeling and imaging in applied geophysics. | Integration of geophysical and hydrogeological methods for environmental and geotechnical applications. | Coastal erosion.

Bernard Giroux | Applied geophysics | bernard.giroux@ete.inrs.ca
Erwan Gloaguen | Geophysics and geostatistics
erwan.gloaguen@ete.inrs.ca
Bernard Long | Marine sedimentology | bernard.long@ete.inrs.ca

HYDROGEOLOGY

Characterization, modeling, and management of groundwater resources. | Contaminant behaviour underground and within aquifers. *In situ* rehabilitation of contaminated sites | Surface and groundwater interactions.

René Lefebvre | Groundwater resources | rene.lefebvre@ete.inrs.ca
Richard Martel | Groundwater resources | richard.martel@ete.inrs.ca
Claudio Paniconi | Hydrogeological modeling
claudio.paniconi@ete.inrs.ca

GEOLOGICAL ENVIRONMENTS AND NATURAL RESOURCES

Sedimentary basin analysis, structure–mineralization relationships, and regional geology. | Geological environments associated with volcanism and magmatism. | Development of models to explain the origin and presence of mineral and oil resources and development of tools for industry to identify areas of high resource potential.

Lyal Harris | Structural geology and geophysics
lyal.harris@ete.inrs.ca
Michel Malo | Structural geology | michel.malo@ete.inrs.ca
Marc Richer-Laflèche | Applied geosciences
marc.richer-lafleche@ete.inrs.ca
Pierre-Simon Ross | Volcanology and economic geology
pierre-simon.ross@ete.inrs.ca

PALEOENVIRONMENTAL STUDIES

Natural dynamics of climatic and hydrological cycles and climate change impacts. | Reconstruction of past environments using biological and sedimentological indicators.

Yves Bégin | Dendroecology | yves.begin@ete.inrs.ca
Pierre Francus | Limnogeology | pierre.francus@ete.inrs.ca

Examples of recent publications

(Centre ETE authors are in **bold**)

- **Boucher, É.**, **Ouarda, T. B. M. J.**, **Bégin, Y.** & **Nicault, A.** (2011). Spring flood reconstruction from continuous and discrete tree ring series. *Water Resources Research*, 47 (7): W07516.
DOI: 10.1029/2010WR010131

- Broda, S., **Paniconi, C.** & Larocque, M. (2011). Numerical investigation of leakage in sloping aquifers. *Journal of Hydrology*, 409 (1-2): 49-61.
DOI: 10.1016/j.jhydrol.2011.07.035

- **Cuven, S.**, **Francus, P.** & Lamoureux, S. (2011). Mid to late holocene hydroclimatic and geochemical records from the sediments of East Lake, Cape Bounty, Canadian high Arctic. *Quaternary Science Reviews*, 30 (19-20): 2651-2665.
DOI: 10.1016/j.quascirev.2011.05.019

- **Dubreuil-Boisclair, C.**, **Gloaguen, E.**, Marcotte, D. & **Giroux, B.** (2011). Heterogeneous aquifer characterization from ground-penetrating radar tomography and borehole hydrogeophysical data using nonlinear Bayesian simulations. *Geophysics*, 76 (4): J13-J25.
DOI: 10.1190/1.3571273

- **Dufréchou, G.**, **Harris, L. B.**, Corriveau, L. & **Antonov, V.** (2011) Gravity evidence for a mafic intrusion beneath a mineralized zone in the Bondy gneiss complex, Grenville Province, Quebec — Exploration implications. *Journal of Applied Geophysics*, 75: 62-76.
DOI: 10.1016/j.jappgeo.2011.06.029

- **Laporte-Saumure, M.**, **Martel, R.** & **Mercier, G.**(2011). Characterization and metal availability of copper, lead, antimony and zinc contamination at four Canadian small arms firing ranges. *Environmental Technology*, 32 (7): 767-781.
DOI: 10.1080/09593330.2010.512298

- **Malo, M.** & **Bédard, K.** (2012). Basin-scale assessment for CO_2 storage prospectivity in the Province of Québec, Canada. *Energy Procedia*, 23: 487-494.
DOI: 10.1016/j.egypro.2012.06.031

- **Paradis, D.**, **Lefebvre, R.**, Morin, R. H. & **Gloaguen, E.** (2011). Permeability profiles in granular aquifers using flowmeters in direct-push wells. *Ground Water*, 49 (4): 534-547.
DOI: 10.1111/j.1745-6584.2010.00761.x

- Pe'eri, S. & **Long, B.** (2011). LIDAR technology applied in coastal studies and management. *Journal of Coastal Research*, Special Issue (62): 1-5.
DOI: 10.2112/SI_62_1

- White, J. & **Ross, P.-S.** (2011) Maar-diatreme volcanoes: A review. *Journal of Volcanology and Geothermal Research*, 201: 1-29.
DOI: 10.1016/j.jvolgeores.2011.01.010

Some research partners

- Cogitore Resources
- Government of Canada (National Defence; Natural Resources)
- Government of Quebec (Health and Social Services; International Relations; Municipal Affairs, Regions and Land Occupancy; Natural Resources; Sustainable Development, Environment, Wildlife and Parks)
- IAMGOLD
- J.A.G. Mines
- Mineral Exploration Research Consortium (CONSOREM)
- Québec City

Research projects of professors, their teams, and collaborators

HYDROLOGY

Watershed hydrology and remote sensing

Monique Bernier

- Acquisition, installation, and monitoring of meteorological stations in the Nunavik communities of Quaqtaq, Kangiqsujuaq, Ivujivik, Puvirnituq, Akulivik, and Umiujaq.
- Avativut: Science in Nunavik – High school students learning in relation to their territory – Remote sensing.
- Continuation of the monitoring of ice around maritime infrastructure in Quaqtaq, Umiujaq, and Kuujjuaq, Nunavik.
- Development of a SMAP algorithm adapted to the Canadian tundra to monitor freeze/thaw soil conditions.
- Development of tools to optimize the use of RADARSAT-2 satellite images in the management of floods, including those caused by ice jams.
- Development of tools to use radar polarimetry as a source of information in hydrology/glaciology.
- High-resolution surface wind mapping in the coastal zone using SAR satellite imagery (WESNet: Wind Energy Strategic Network).
- North Hydrology (European Space Agency Support to Science Element).
- Permafrost and climate change in northern coastal Canada: Impacts and adaptations for communities (ArcticNet).
- Planimetric map referencing of drill holes in Montérégie and determination of their elevation.
- Study of sea ice and freshwater ice behaviour around maritime infrastructure in Nunavik – Contribution of local knowledge and remote sensing.

Karem Chokmani

- Characterization of riparian vegetation strips using very-high-resolution satellite imagery.
- Characterization of soil salinity using satellite radar images and object-oriented classification in Tunisia and Morocco.
- Development of a strategy for mapping snow using remote sensing data and ensemble-based estimation.
- Development of an operational methodology for flood risk dynamic mapping in urban areas.
- Development of stochastic approaches for spatial and temporal monitoring of snow cover using remote sensing data.
- Mapping of soil erosion by water using very-high-resolution satellite imagery – Application to farmlands close to riparian vegetation strips.
- Using airborne LIDAR intensity data to identify tree species.

Alain Rousseau

- Adapting PHYSITEL/HYDROTEL models for the boreal zone of Quebec: Hydrological process modeling and analyses of sensitivity, identifiability, and uncertainty (Alain Mailhot and André St-Hilaire's teams are also involved).
- Contribution of multipurpose agroforestry systems to the ability of agro-ecosystems to adapt to climate change.
- Hydrological modeling of the Bras d'Henri watershed and development of an integrated economic and hydrological model (GIBSI).
- Taking climate change impacts into account in the estimation of maximum probable flood for evaluations of dam safety (Alain Mailhot's team is also involved).
- Tools to carry out hydrological, economic, and spatial analyses of the ecological services offered by wetlands of the St. Lawrence Lowlands.
- Using and improving distributed hydrological modeling for watershed-based management.

Jean-Pierre Villeneuve

- Integrated management of the Cau River watershed (Vietnam).
- Mathematical models to improve management of water resources.

Urban hydrology and climate change

Sophie Duchesne

- Hydrological simulation to estimate fecal coliform loads reaching Beauport River.
- Mathematical models applied to water and infrastructure management.

Alain Mailhot

- Analysis of precipitation extremes simulated by the Canadian Regional Climate Model.
- Development of indices to characterize dam effects on hydrometric data.
- Impacts of climate change and adaptation solutions for municipal water infrastructure in Rivière des Prairies.
- Rainwater management and climate change.
- Update of standards and procedures used in the design of hydro-agricultural structures in relation to climate change.
- Urban hydrology and infrastructure in relation to climate change.

Jean-Pierre Villeneuve

- Water governance in municipalities.

Environmental hydraulics

Normand Bergeron

- Aerial imagery of the Restigouche River.
- Evaluation of the impacts of forest road culverts on habitat fragmentation for the brook trout (Patrice Couture and Taha B.M.J. Ouarda's teams are also involved).
- Evaluation of the impacts of the seaweed *Didymosphenia geminata* on juvenile Atlantic salmon in the Restigouche River watershed (Patrice Couture's team is also involved).
- Fluvial geomorphology and the winter river habitat of salmonids.

- Modeling of the capacity of brook trout (*Salvelinus fontinalis*) to pass through road culverts.
- Proof of concept of a multiple-antenna system to detect passive transponders used to monitor salmonids.

Normand Bergeron et André St-Hilaire

- Critical thermal refuges for Atlantic salmon and brook trout populations of eastern Canadian rivers.
- Hydrocarb: A national research network to promote sustainable hydropower and healthy aquatic ecosystems.

Yves Secretan

- 2D advection–diffusion model of the St. Lawrence fluvial estuary in the Québec City area.
- Development and improvement of the hydrodynamic model of the St. Lawrence.
- Integration of road culverts into the H2D2 software.
- LIDAR survey of the St. Lawrence riverbanks between Montmagny and Trois-Rivières.

André St-Hilaire

- Improved understanding of the sedimentation, circulation, and ecology of Saint John Harbour (NB).
- Monitoring of water turbidity upstream and downstream from two sedimentation basins draining water from peatland 324 North.
- Sustainable management of paludified forests.

Statistical hydrology and climatology

Fateh Chebana

- Relationship between cardiovascular diseases and meteorology/climate in Quebec.
- Study of hydrological variables in south-eastern Algeria.
- Study of hydrological variables using functional data analysis.
- Use of flexible and optimal statistical methods for regional frequency analysis of physical variables.

Taha B.M.J. Ouarda

- Canada Research Chair in Hydrometeorological Variable Assessment.
- Design and operation of hydraulic structures taking into account variability and change.
- Facing changes together (FACE): Adaptation of water resource management to climate change in Canada and Western Africa.

André St-Hilaire

- Inclusion of spatial and temporal data for optimal management of riverbanks within the context of environmental changes.
- Modeling and statistical analysis of water quantity and quality for estimating controlled flows.
- Statistical analysis of surface water quality networks with an emphasis on station location and sampled variables.
- Towards a regional monitoring framework for cumulative impacts assessment in the Northumberland Strait: Linking land-use, stressor loads and nearshore biological integrity (Canadian Water Network).

DECONTAMINATION AND RECLAMATION

Environmental decontamination

Jean-François Blais

- Coupling sulphur-based autotrophic denitrification with biological treatment of residential wastewater to be used in decentralized water treatments (Guy Mercier's team is also involved).
- Decontamination of soils polluted by pentachlorophenols, dioxins, furans, and metals (Guy Mercier's team is also involved).
- Immobilization and recovery of metals from reactive mixtures of biofilters used to treat acid mine drainage (Guy Mercier's team is also involved).
- Treatment of matrices contaminated by toxic metals.

Patrick Drogui

- Development of an electrolytic treatment for industrial wastewater contaminated by pentachlorophenol-type phenolic compounds.
- Development of electrolytic and membrane technologies to treat wastewater contaminated by hormone-disrupting chemicals and other pollutants.
- Development of electrotechnologies to treat wastewater contaminated by hormone-disrupting chemicals and other inorganic and microbial pollutants.
- Development of innovative electrolytic technologies adapted to decentralized treatment and management of wastewater in rural, peri-urban, and urban areas (Jean-François Blais and Guy Mercier's teams are also involved).
- Development of innovative electro-membrane processes to treat water and effluents contaminated by emerging micropollutants (Quebec–Mexico Network Program).
- Development of innovative electro-photo-catalytic processes using nanostructured electrodes to extract emerging pollutants from water.
- Development of innovative technologies adapted to decentralized wastewater treatment bioprocesses in rural, peri-urban, and urban areas.
- Electrolytic and advanced oxidation treatment of water and effluents contaminated by refractory emerging micropollutants (Quebec–Shandong Network Program).

Guy Mercier

(Jean-François Blais' team is involved in these projects)

- Reclamation of waste from metallurgical industries for their value in primary and secondary metals.
- Simultaneous extraction of organic and metal pollutants from contaminated soils by leaching in saline medium and use of non-toxic zwitterionic surfactants.
- Technological development of a treatment for contaminated soils by simultaneous extraction of PAHs and metals (Green Technology Demonstration Program).
- Trapping industrial CO_2 to produce carbonates: Reclamation of asbestos waste and other ultrabasic residual materials produced in Quebec.
- Treatment and reclamation of soils and waste containing metals and/or polycyclic aromatic hydrocarbons (PAHs).
- Treatment of industrial wastewater.

Waste and biomass reclamation

Jean-François Blais

- Recycling of wood treated with metallic preservatives (Patrick Drogui and Guy Mercier's teams are also involved).

Satinder Kaur Brar

- Biohydrogen production and reclamation of agro-industrial waste (Rajeshwar Dayal Tyagi's team is also involved).
- Comparison of yeast extracts used as fermentation ingredients to enhance biopesticide yield.
- Integrated solid state fermentation approach for the production of enzymes and high-value-added products from fruit processing waste (Rajeshwar Dayal Tyagi's team is also involved).
- Monitoring the fate of toxic organic compounds at all steps between wastewater treatment plants and processes of reclamation and enzymatic detoxification.
- Utilization of economically efficient flocculants for sedimentation of brewery fermented liquor (Rajeshwar Dayal Tyagi's team is also involved).

Rajeshwar Dayal Tyagi

- Canada Research Chair in Bioconversion of Waste Water and Sewage Sludge into High-Value-Added Products.
- Econo-efficient formulations of *Bacillus thuringiensis*–based biopesticides (Satinder Kaur Brar's team is also involved).
- Production of animal feed (L-base) from whey (Satinder Kaur Brar's team is also involved).
- Production of lipids using new sludge-isolated microorganisms and sewage sludge as base material to obtain biodiesel.
- Technology transfer of a new efficient formulation of Btk-based biopesticide (Satinder Kaur Brar's team is also involved).

BIOGEOCHEMISTRY

Environmental geochemistry

Charles Gobeil

- Fallout of contaminants and reactive transport in aquatic environments.
- Geochemistry of trace elements in aquatic environments (INRS honorary researcher André Tessier is also involved).

Pierre Lafrance

- Pesticide transfer to hydrosystems and prevention of environmental impacts.
- Use of grassed waterways and buffer strips as beneficial management practices to reduce surface water contamination by herbicides.

Aquatic ecotoxicology

Peter G.C. Campbell

- Canada Research Chair in Metal Ecotoxicology.
- Speciation, geochemistry, and ecotoxicology of trace metals in aquatic environments (Patrice Couture, Claude Fortin, and Landis Hare's teams are also involved).

Patrice Couture

- Accumulation of complex blends of metals and their effects in fish.
- Combined effects of natural and anthropogenic stressors in fish.
- Development of a microarray to detect metal stress in yellow perch.
- Impacts of habitat contamination on the health of declining American and European eel populations (Peter G.C. Campbell's team is also involved).

Paul Drevnick

- Fish health in a hot spot for mercury contamination in Quebec: La Mauricie National Park.
- Investigation of mercury toxicity in landlocked char in High Arctic lakes (Peter G.C. Campbell and Claude Fortin's teams are also involved).
- Methylmercury in fish: Understanding its effects and identifying approaches to decrease exposure.

Claude Fortin

- Bioassessment of the ecological integrity of lakes and streams of Gatineau Park using diatoms and other groups of algae.
- Canada Research Chair in Biogeochemistry of Trace Elements.
- Detection and quantification of nanomaterials in the environment (Peter G.C. Campbell's team is also involved).
- Development of a diatom index for river bioassessment in Ontario.
- Development of prediction models for the bioavailability of trace elements in aquatic environments.
- Green aluminum plants – Bioavailability and retention of emissions in the environment.
- Identification of indicators of water quality for headstreams of Gatineau Park and for La Pêche River: Application of the Eastern Canadian Diatom Index (IDEC).
- Metals in the environment: Reducing risks and promoting sustainable development (Peter G.C. Campbell's team is also involved).
- Tracking silver nanomaterials in aquatic environments (Peter G.C. Campbell's team is also involved).

Landis Hare

- Using freshwater animals to understand trace element exposure in natural ecosystems.

Limnology

Yves Gratton

- Impacts of climate change on salmon habitats in northern lakes in Quebec (Isabelle Laurion and André St-Hilaire's teams are also involved).

Isabelle Laurion

- Freshwater resources of the Eastern Canadian Arctic (ArcticNet).
- Microbial dynamics in aquatic environments: Influence of thermal and light regimes.

Oceanography

Yves Gratton

- Long-term observatories in Canadian Arctic waters (ArcticNet).
- Marine biological hotspots: Ecosystem services and susceptibility to climate change (ArcticNet).
- Mesoscale physical processes and their impact on biogeochemical processes.
- Modeling of ecosystem responses to climatic variations in the southern part of the Beaufort Sea.

GEOSCIENCES

Geophysics

Bernard Giroux

- Geophysical study of deep aquifers within the context of energy resource management.
- Study of seismic detection to discriminate detonation reactions in military training areas (Erwan Gloaguen and Richard Martel's teams are also involved).

Erwan Gloaguen

- Geostatistical integration of borehole geophysical and hydrogeological data for the characterization of aquifers at local and regional scales.
- Geostatistical modeling of the subsurface velocity field of Sabine Peninsula, Nunavut.

Hydrogeology

René Lefebvre

- Analysis of aquifers in fractured bedrock (GSC-Qc researcher Christine Rivard is also involved).
- Characterization and modeling of heterogeneity in local and regional aquifer systems.
- Groundwater Knowledge Program in Chaudière-Appalaches (Erwan Gloaguen's team and GSC-Qc researcher Michel Parent are also involved).
- Groundwater Knowledge Program in Montérégie-Est (Erwan Gloaguen, Richard Martel, and Claudio Paniconi's teams and GSC-Qc researchers Michel Parent and Christine Rivard are also involved).
- Hydrogeological synthesis in relation to shale gas.
- Installation of observation wells in Montérégie-Est (Quebec Groundwater Monitoring Network).
- Regional hydrogeochemical characterization to contribute to an integrated understanding of aquifer systems (GSC-Qc researcher Christine Rivard is also involved).
- Scientific support to the development of the conceptual model for the Milk River Aquifer (GSC-Qc researcher Alfonso Rivera is also involved).

Richard Martel

- Environmental fate of energetic materials.
- Mapping of risk zones for radon exposure in Quebec.
- Optimization of the use of surfactant solutions in the set of technologies used for the rehabilitation of organically contaminated heterogeneous soils (René Lefebvre's team is also involved).
- Rehabilitation/management of soils contaminated by ammunition residues in training areas of Canadian military bases.
- Research work to assist in the installation of drinking water intakes at the surface and underwater in the Montmorency River (René Lefebvre and Claudio Paniconi's teams are also involved).
- Sustainable exploitation of groundwater and groundwater vulnerability in the Toluca Valley Aquifer, Mexico (GSC-Qc researcher Alfonso Rivera is also involved).

Claudio Paniconi

- CLIMB: Integrated approaches for reducing uncertainties in analyses of climate change impacts on water resources (Monique Bernier, Karem Chokmani, and Taha B.M.J. Ouarda's teams are also involved).
- Guide for the installation of drinking water intakes in river banks and underwater in Quebec (René Lefebvre and Richard Martel's teams are also involved).
- Integrated hydrological modeling to improve management of water resources and analysis of climate change impacts.
- Integrated physically based modeling of hydrological processes at hillslope and catchment scales.

Geological environments and natural resources

Lyal Harris

- Development of new Archaean tectonic models – Conceptual analysis and analogue models (GSC-Qc researcher Jean Bédard is also involved).
- Effect of deep crust and upper mantle structures on the location of mineral deposits and kimberlite emplacement.
- Structural, geochemical, and geophysical research applied to mineral exploration in the Grenville Province of southwestern Quebec (Marc Richer-Laflèche's team and GSC-Qc researcher Louise Corriveau are also involved).
- Transpressive dynamics and effect of crustal heterogeneities on the location of the Desmaraisville Basin (Abitibi): Geophysical study and analogue modeling.

Michel Malo

- Research Chair on CO2 Geological Storage (Bernard Giroux, Erwan Gloaguen, René Lefebvre, and Normand Tassé's teams and GSC-Qc researcher Mathieu J. Duchesne are also involved).
- Study of gold deposits in Musselwhite and Meadowbank banded-iron formations (GSC-Qc researchers Benoît Dubé and Patrick Mercier-Langevin are also involved).
- Study of the Westwood deposit, Abitibi (GSC-Qc researchers Benoît Dubé and Patrick Mercier-Langevin are also involved).
- Synthesis of thermal maturity in the Foxe Basin, Hudson Bay (GSC-Qc researcher Denis Lavoie is also involved).

Marc Richer-Laflèche

- CSAMT (Controlled Source Audio-frequency Magnetotelluric) and frequency domain electrical conductivity surveys on the Lac Saint-Jean Property.
- Electromagnetic induction, gravimetric, radiometric, pedogeochemical, and electrical resistance studies of the Témiscouata Property.
- Gravimetric study in the Pohénégamook Region, Bas-Saint-Laurent (Phase I).
- Study of geoelectrical properties of the geological formations associated with the graben of the Gouffre River, Baie-St-Paul, Quebec.
- Study of the mineralization potential of the Belleterre Project (Abitibi – Phase I: Polymetallic and gold mineralization.

Pierre-Simon Ross

- Development of a large database of petrophysical, geochemical, and mineralogical data using a semi-automated multiparameter analysis system for drill cores (Erwan Gloaguen's team is also involved).
- Geology of the Lalor Deposit, Manitoba (GSC-Qc researcher Patrick Mercier-Langevin is also involved).
- Maar-diatreme volcanoes and kimberlites (Lyal Harris's team is also involved).
- Multi-sensor core logging in the Matagami mining camp.
- New concepts and tools for exploration of volcanogenic massive sulphide deposits in Matagami (GSC-Qc researcher Patrick Mercier-Langevin is also involved).
- Volcanic architecture of the Waconichi Formation, Chibougamau, Abitibi Subprovince – Implications for finding and understanding volcanogenic massive sulphide deposits (GSC-Qc researcher Patrick Mercier-Langevin is also involved).

Paleoenvironmental studies

Yves Bégin

- ARCHIVES: Retrospective analysis of hydro-climatic conditions using indicators of their century-scale variability (Pierre Francus' team is also involved).
- Freshwater resources of the Eastern Canadian Arctic (ArcticNet).
- Secular trend of the seasonal hydrological regimes at the boreal–subarctic interface in eastern Canada.

Pierre Francus

- Canadian participation in the International Continental Scientific Drilling Program (ICDP).
- Climate of high-latitude areas during "warm" periods of the recent past: Validation of the numerical models used to simulate future climate.
- Participation in the VARVES Working Group (PAGES).
- PASADO Canada: Canadian participation in the Potrok Aike Maar Lake Sediment Archive Drilling Project.
- Reconstruction of past climate variability in Arctic regions from varved sediments.
- Reconstruction of past climate variability in desert regions from varved sediments.

Publications

30 ans de géosciences à l'INRS

Du Groupe Pétrole au Centre Géoressources 1971-2001

www.ete.inrs.ca/ete/publications#Livres_Histoire_INRS

Aicha Achab, honorary professor and director of the Centre INRS-Géoressources from 1988 to 2001, was the editor of this history of 30 years of geoscience research at the INRS. The book was published in November for the 10th anniversary of the Centre Eau Terre Environnement.

Journal of Water Science

www.rse.inrs.ca

An international electronic journal co-edited by the Groupement d'intérêt scientifique des sciences de l'eau (France) and the Centre Eau Terre Environnement (INRS).

Scientific publications

A complete list of the 2011-2012 publications and communications of the Centre's researchers is available online:

www.ete.inrs.ca/ete/publications#rapports_annuels

Most of the Centre's research reports and graduate theses are available online:

www.ete.inrs.ca/ete/publications/rapports

www.ete.inrs.ca/ete/publications/theses-memoires

Capsules INRSciences

www.ete.inrs.ca/ete/publications#CapsulesINRSciences

Information bulletins highlighting in easily understood language the research carried out by students from the Centre.

Events, seminars and meetings

Tenth anniversary of the Centre Eau Terre Environnement

http://10ans.ete.inrs.ca

The 10th anniversary of the Centre was celebrated on 30 November 2011. In 2001, the INRS decided to group some of its research centres according to multidisciplinary themes. The Centre Eau Terre Environnement was officially created on 27 November 2001 by merging the INRS-Eau and Géoressources centres.

Seminar program

The Centre holds scientific seminars related to its research fields throughout the year.

Conferences, meetings, and workshops

August 28–31, 2011: The GeoHydro 2011 conference was held in Québec City. This conference was organized by two researchers from the Centre géoscientifique de Québec, Richard Martel (INRS) and Yves Michaud (GSC-Qc). The two organizers were later honoured by the Cercle des ambassadeurs de Québec for the international exposure the conference gave to the region.

September 1st: The Centre Eau Terre Environnement hosted a series of presentations about the North to celebrate the 50th anniversary of the CEN (Centre for Northern Studies), a strategic research alliance that includes INRS. The activity was organized by CEN Co-director and INRS professor Monique Bernier.

October 7th: The 26th Eastern Canadian Symposium on Water Quality Research of the Canadian Association on Water Quality (organized by Professor Rajeshwar Dayal Tyagi and his team) was held at the Centre.

March 7–9, 2012: A CT Scan Workshop focusing on developments in non-medical imaging (co-organized by Professor Bernard Long) was held in Québec City.

March 19–21: Canada Waterweek activities took place at the Centre. Organized by the Student and Young Professionals Chapter of the Canadian Water Resources Association (CWRA), events included a workshop about the WET (Water Education for Teachers) Program, a seminar on water management, and a panel discussion on the development of the North.

March 30th: The 13th JSTE (Journée des Sciences de la Terre et de l'Environnement) meeting, an annual event at which graduate students of the joint INRS–Université Laval Earth Science Program present their research projects, was held at the Centre. The meeting was organized this year by INRS students.

April 19th: Pilot Projects of CO_2 Capture, Transport and Geological Storage, the 4th Annual Meeting of the Research Chair on CO_2 Geological Storage, was held at the Centre. The meeting was organized by Professor Michel Malo and his team.

Research excellence

Several members of the Centre received awards this year for the excellence of their research or the quality of their scientific communications.

For example, many of our students were recognized for the high quality of their oral or poster presentations in national and international conferences.

- Carole-Anne Gillis (Master's) and Elsa Goerig (PhD), both on Normand Bergeron's team: Two of the three best oral presentations at the 14th CIRSA Annual Meeting (May 5–6, 2011)
- Kristin Mueller (PhD supervised by Peter G.C. Campbell): Best oral presentation at the 94th Canadian Chemistry Conference and Exhibition (June 5–9)
- Yann Dribault (Master's co-supervised by Karem Chokmani and Monique Bernier): Second best oral presentation at the joint meeting of the 32nd Canadian Symposium on Remote Sensing and the 14th Congress of the Association québécoise de télédétection (June 13–16)
- Valérie Ouellet (PhD) and Sandra Proulx-McInnis (Master's graduate), both on André St-Hilaire's team: Second best oral presentation and best poster, respectively, at the 64th CWRA (Canadian Water Resources Association) National Conference (June 27–30)
- Charles Gignac (Master's supervised by Monique Bernier): Best Student Paper Award at the 21st International Conference on Port and Ocean Engineering under Arctic Conditions (July 10–14)
- Geneviève Bordeleau (PhD supervised by Richard Martel): IAGC (International Association of Geochemistry) Faure Award at the 9th International Symposium on Applied Isotope Geochemistry (September 19–23)
- Frédéric Bouchard (PhD supervised by Pierre Francus): Louis-Edmond Hamelin Award at the 31st CEN (Centre for Northern Studies) Annual Symposium (February 9–11, 2012)

Three students at the Centre received graduate scholarships from the CREATE Program of NSERC. The WATER (Watershed and Aquatics Training in Environmental Research) Program of the Canadian Rivers Institute granted scholarships to Audrey Maheu (PhD) and Sébastien Ouellet-Proulx (Master's), both on André St-Hilaire's team. Karita Neghandi (PhD supervised by Isabelle Laurion) received an EnviroNorth Research Fellowship.

Carole-Anne Gillis, PhD student supervised by Norman Bergeron, received a scholarship from the Gérard D. Lévesque Fund, which encourages students to pursue graduate studies on research themes likely to benefit the development of their home region.

On June 15, 2011, at the joint meeting of the 32nd Canadian Symposium on Remote Sensing and the 14th Congress of the Association québécoise de télédétection, Monique Bernier received the Ferdinand-Bonn Award for her exceptional contribution to the development and advancement of remote sensing in Quebec.

On October 11th, Emeritus Professor Bernard Bobée received the Adrien Constantin de Magny Award from the Science Academy of France for the outstanding quality of his research work.

On November 20th, several of the Centre's graduates were honoured at the INRS convocation ceremony for their personal achievements: Hélène Higgins (Master's supervised by André St-Hilaire) for her leadership, Russel Rogers (Master's supervised by Pierre-Simon Ross) for his international outreach, Vincent Taillard (Master's supervised by Guy Mercier) for his innovation, François Zaviska for the best PhD thesis (supervised by Patrick Drogui), and Lorenzo Perozzi for the best Master's thesis (supervised by Erwan Gloaguen).

In December, Professor Pierre-Simon Ross's Mobile Laboratory for the Physical, Chemical, and Mineralogical Characterization of Rocks was selected by Minalliance as one of the 100 most important innovations for the mining industry in Quebec in the last 10 years.

On February 9, 2012, Tarek Rouissi (PhD student co-supervised by Rajeshwar Dayal Tyagi and Satinder Kaur Brar) received a grant from the AQSSS (Association québécoise de spécialistes en sciences du sol) to participate in the 11th Soil Study Day to be held in France on March 19–23.

On March 30th, several students were honoured for the quality of their presentations at the JSTE (Journée des Sciences de la Terre et de l'Environnement). Honorees included Jean-François Montreuil (PhD student co-supervised by Louise Corriveau from GSC and Pierre-Simon Ross from INRS) for the best presentation in "Geodynamics and Resources"; Maude Naulier (PhD with Martine M. Savard from GSC) for the best presentation in "Environmental and Isotopic Geochemistry"; Bastien Fresia (Master's with Pierre-Simon Ross) for the best presentation in "Geophysics and Geostatistics"; and Genevieve Bordeleau (PhD with Richard Martel) for the best presentation in "Hydrogeology and Geo-engineering".

At the end of April, Valérie Ouellet received one of four graduate student awards of merit presented to women for outstanding leadership at the SWAAC (Senior Women Academic Administrators of Canada) Annual Conference. These awards are granted only every four years in Quebec. Valérie is currently pursuing a PhD under the supervision of André St-Hilaire.

Public outreach

Researchers at the Centre regularly give interviews and contribute to articles in the media (newspapers, radio, television, Internet) within their specialty field.

In 2011-2012, the following professors were featured in outreach articles about their research work in the online magazine *Planète INRS*: Alain Rousseau, Isabelle Laurion, Sophie Duchesne, Satinder Kaur Brar, Alain Mailhot, Patrice Couture, Pierre Francus, Pierre-Simon Ross, and Patrick Drogui.

Throughout the year, Adéline Parent (PhD student from Michel Malo's team) presented a series of popular summaries of science topics on the radio show *Futur simple* at CKRL. Karine Bédard and Jean-Philibert Moutonet (also from Michel Malo's team) and Samuel Bolduc (Alain Mailhot's team) also took part on one occasion.

In spring 2011, historic floods occurred in the Montérégie region. Hydrology specialists Alain Mailhot, Alain Rousseau, and Emeritus Professor Michel Leclerc were sought out on several occasions by Radio-Canada for their expertise on the subject.

In July, a group of scientists including professors Normand Bergeron and André St-Hilaire publicly denounced the government decision to allow reconstruction in flood-prone areas.

On May 10th at the 79th Annual ACFAS (Association francophone pour le savoir) Conference, Professor Alain Rousseau participated in a panel discussion entitled "Toward effective water governance in Quebec". This discussion was broadcast on television in November.

In August, ten students from the Centre went to Nicaragua for a project of international cooperation. The project's objective was to analyse potable water quality for two small communities to help them assess the quality of their water supply and solve potential contamination problems. The project was integrated into the curriculum of the students involved. The outcomes are available on the project's website and were published in the online magazine *Planète INRS*.

Also in August, Professor Paul Drevnick participated in the open house organized at the Resolute Facility of the Polar Continental Shelf Program (Natural Resources Canada), performing fish dissections for visitors.

On August 16th, INRS and Université Laval announced the discovery of the deepest lake of Quebec, Lake Walker in the Côte-Nord Region, by researchers from the Centre for Northern Studies (CEN). INRS Professor Pierre Francus, who was part of the discovery team, gave several interviews to the media. The discovery was featured in more than 15 newspaper and radio reports.

On September 16th, the Centre participated in the annual PARK(ing) Day to raise the awareness of city dwellers about the space occupied by cars in urban areas. This year's theme was "Where does the water go in cities?" A parking space in front of the downtown building was converted for a few hours into a popular science café featuring information on urban hydrology. Professor Alain Mailhot's team provided support on the scientific aspects.

In October, Professor Claude Fortin published an article in *Forêt Savoir*, the bulletin of the Gaspésie-Les-Îles Forestry Research Consortium, on the impacts of logging on lakes in the Chic-Choc Mountains. On November 19th, Professor Fortin made a presentation on the ecological integrity of the lakes of Gatineau Park at the park's Annual Research Symposium.

Between November 6th and 16th, Professor Charles Gobeil visited several universities in Western Canada to talk about his work on element cycling in the Arctic Ocean. The lecture tour was sponsored by the Canadian National Committee for SCOR (Scientific Committee on Oceanic Research).

On November 29th, Professor Alain Rousseau was a guest on the popular science television show *Le Code Chastenay*. He was asked to answer the following question: "Will hydroelectric dams stand the test of climate change?"

On December 21st, Radio-Canada's popular science television show *Découverte* broadcast a report on archeometallurgy in which Professor Bernard Long's CT scanner was used to analyze historical artefacts.

On December 31st, the newspaper *Le Soleil* published a list of the top 10 scientific breakthroughs of 2011. One of the 10 concerned the gradual disintegration of the Ward Hunt ice shelf in the Canadian High Arctic, which Professor Pierre Francus is helping to monitor.

In February 2012, following the publication of a government report on surface water quality in Quebec for 1999 to 2008, Professor Patrice Couture was interviewed on the radio and by the newspaper *Le Soleil* about the contamination of lakes in the Abitibi Region.

On March 12th, on the occasion of the opening of the 6th World Water Forum, Professor Alain Rousseau was interviewed by several radio stations (Quebec, Ontario, the Maritimes) on the topic of good water management.

In March, Carole-Anne Gillis (PhD student from Norman Bergeron's team) published an article about the invasive seaweed dydimo in the magazine *Faune gaspésienne*. She also contributed to an article on the same subject published in the newspaper *Le Soleil* in October 2011.

In April, oil and gas exploitation in Quebec was in the spotlight. Professor Michel Malo's expertise on the subject was sought out on several occasions by the media. Articles were published in Quebec's main newspapers, and an in-depth report appeared in the April–May issue of *Québec Science* magazine.

On April 21st, as part of Canada Waterweek, five professors (Monique Bernier, Normand Bergeron, Erwan Gloaguen, Alain Rousseau, and Normand Tassé) participated in a panel discussion at the Centre about the potential impacts on water resources of development in the North. Normand Bergeron gave an interview to the newspaper *Le Devoir* on the conclusions of this panel for an article published the same day.

On April 23rd and 24th, three short videos were posted on YouTube to promote laboratories at the Centre financed by the Canadian Foundation for Innovation. The three laboratories were Professor Guy Mercier's Environmental Technologies Mobile Laboratory, Professor Bernard Long's CT Scan Multidisciplinary Laboratory, and Professor Rajeshwar Dayal Tyagi's Bioconversion of Waste Water and Sludge into High-Value-Added Products Laboratory.

On April 27th, the Canada.com website published an article about scientists' plans to drill in the Beaufort Sea to investigate the methane emission potential of seafloors. Professor Pierre Francus was interviewed for this article. In the days that followed, news of the project was reported in several newspapers throughout the country.

Graduate studies

www.inrs.ca/english/research-centres/ete/graduate-studies

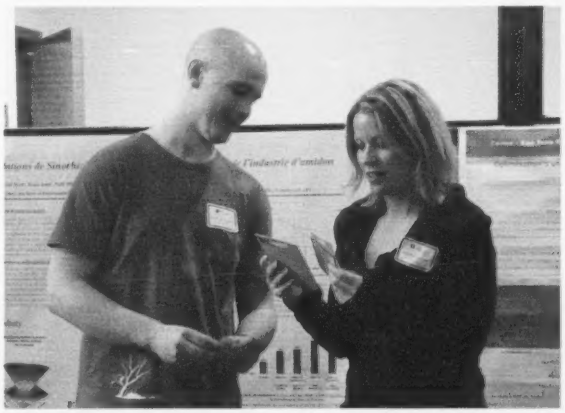
Six graduate programs are offered at the Centre Eau Terre Environnement in water and earth sciences. The inter-university Master's and PhD programs in earth sciences are operated in collaboration with the Geology and Geological Engineering Department of the Université Laval. Students are registered in the institution of their supervisor but are trained by both institutions.

Master's degrees

- Master's in Water Sciences
- Professional Master's in Water Sciences
- Master's in Earth Science
- Master's in Earth Sciences – Environmental Technologies

PhD degrees

- PhD in Water Sciences
- PhD in Earth Sciences



INRS PhD student Geneviève Bordeleau (right) and an unidentified Université Laval student (left) attend the JSTE (Journée des Sciences de la Terre et de l'Environnement), a joint INRS-UL event for earth science graduate students.

Internships and fellowships

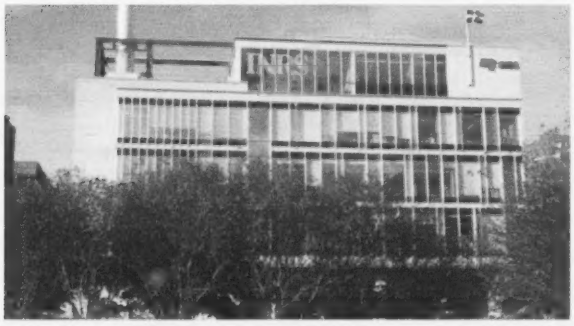
The Centre Eau Terre Environnement welcomes postdoctoral associates in its research teams. INRS postdoctoral fellowships are available. The Centre also offers undergraduate summer internships, which provide an excellent opportunity for students to gain research experience in a highly stimulating scientific environment.

INRS postdoctoral fellowships:
www.inrs.ca/english/graduate-studies/postdoctoral-fellowship

The Centre's summer internships (in French only):
www.ete.inrs.ca/ete/etudier/projets-etudes-stages

Postdoctoral research associate Dae Il Jeong and Professor André St-Hilaire doing field work in hydrology.

The Centre's high-tech laboratories and specialized equipment combine with its researchers' high level of expertise to contribute to the Centre's mission of education, applied research, and innovation.



INRS building in downtown Quebec City

The Centre's main infrastructure comprises modern research laboratories, large-scale laboratories, mobile facilities, and a field station.

The **research laboratories** are located on the urban campus of the Université du Québec in downtown Québec City. They include a very complete set of analytical equipment essential for advanced research work, and extensive modeling and data processing capabilities. For example, the Centre possesses a class 1000 clean room with a class 100 workspace, controlled environmental chambers, and the necessary equipment to prepare geological samples.

The **Laboratories for scientific and technological innovation in environment (LISTE)** are located in the Metropolitan Québec Technology Park. Among other purposes, these laboratories are used for the scaling of technologies developed in partnership with industry. The experimental pilot equipment is used to analyse the economic viability of technological innovations. These laboratories constitute a major asset for Quebec and Canadian enterprises.

Laboratories in the Technology Park

The Centre also has **mobile facilities** enabling on-site specialized work in environmental decontamination, hydrogeology, and geological analysis.

The **CIRSA field research station**, located at Sacré-Cœur in the Saguenay region near the mouth of the Sainte-Marguerite River, offers the Centre's research teams a workspace in a natural environment of exceptional quality. The station comprises a laboratory and accommodations for up to 30 persons.

These facilities support basic and applied research related to hydrology, biogeochemistry, geological sciences, and environmental decontamination and waste reclamation.

CIRSA station in the Saguenay region

These innovation tools and associated expertise are accessible to enterprises and governments via collaborative research projects oriented towards their specific needs. The Centre thus offers opportunities for economic actors and regulatory agencies to contribute to the improvement of knowledge while serving their respective missions.

FOR MORE INFORMATION, PLEASE CONTACT: **Carole Parent**, liaison officer, **carole.parent@ete.inrs.ca**, 418 654-2531

RESEARCH LABORATORIES

The research laboratories comprise a general laboratory and several specialized laboratories as well as microscopy and sample preparation rooms. The specialized laboratories enable the analysis of water samples by colorimetry, fluorometry, radio-isotopy, and chromatography, the analysis of organic compounds and trace metals contained in various matrices (water, effluent, sewage sludge, soil, sediment, biological tissues), and the analysis of different elements contained in solid samples (rock, soil, sediment, sludge).

FOR MORE INFORMATION, PLEASE CONTACT: **Stéfane Prémont**, head of laboratory services, stefane.premont@ete.inrs.ca

X-ray fluorescence scanner

A non-destructive tool for chemical analysis by XRF (X-ray fluorescence) scanning and micro-radiography analysis of rock, soil and sediment

The **ITRAX™** Core Scanner enables the simultaneous acquisition of very high resolution (100 µm) data on density and structural variations, chemical composition, and optical image of samples. Most elements can be measured using XRF, from aluminum to uranium. Rocks, drill cuttings and other fine materials, and split sediment cores and U-channels of up to 1.8 m in length can be analysed.

One of the uses of this equipment is to analyse lake and marine sediments in order to reconstruct past climates at various temporal scales.

ITRAX™ Core Scanner

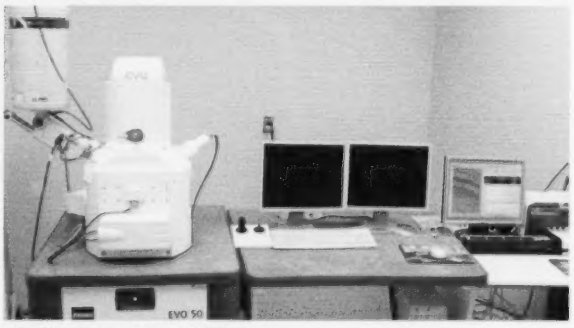
CONTACT:
Dr. **Pierre Francus**, pierre.francus@ete.inrs.ca

Scanning electron microscope

High-resolution imaging of the surface of a sample using a technology based on the interactions between electrons and a sample's atoms

Using the **Zeiss EVO® 50** SEM (scanning electron microscope), it is possible to obtain images of the surface of most solid materials, with magnifications from 100X to 60 000X.

The SEM is equipped with three types of detectors for various applications: morphological characterization (secondary electron detection), phase atomic density and granulometry (backscattered electron detection), and chemical composition analysis and element distribution mapping (x-ray detection). The SEM can be used to observe samples in controlled-pressure environments, eliminating the need for preliminary metallization.



Scanning electron microscope (SEM)

CONTACT:
Dr. **Pierre Francus**, pierre.francus@ete.inrs.ca

Aquatic biogeochemistry and limnology

Analysis of trace metals in liquid or solid samples (biological tissues, suspended matter, sediment, soil) and bio-optical analysis

The main instruments used for trace metal analysis are

- Radioactivity and particle counters (beta and gamma emissions)
- Atomic absorption spectrophotometer (combined flame and graphite furnace)
- Inductively coupled plasma atomic emission and mass spectrometers (ICP-AES and ICP-MS)
- Liquid, gas, and ion chromatography systems (HPLC, LC-MS-MS, GC, GC-MS)
- Mercury analyzer

These instruments support research on the transfer of toxic metals within food chains, the bioavailability of contaminants, the impacts of anthropogenic activities, and the sensitivity of the natural environment to metal contamination.

Gas chromatography system

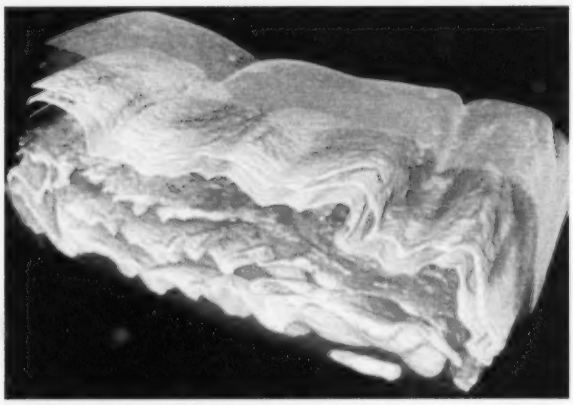
Limnology work focuses on the impacts of climate change on water mixing dynamics and transparency in lakes, and on their interaction with the microbial food chain. Bio-optical work focuses on counting and characterizing microorganisms, monitoring their fluorescence, describing their morphometry and taxonomy, and studying their physiology.

CONTACT:
Stéfane Prémont, stefane.premont@ete.inrs.ca

Geodynamics

Structural and tectonic interpretation of field and geophysical data and simulation of geological processes to assist mineral and oil prospecting

Field studies and advanced geophysical data processing combined with physical, numerical, and geophysical simulations enable researchers to interpret the geometry and evolution of geological structures and to identify the structural and tectonic controls of mineral deposits and oil traps. The progressive deformation of the physical simulation models can be observed using computed tomography.



3D image of a folding model in a channel flow

The main equipment includes

- High-speed centrifuge (1000 *g*), which enables the scaling of deformation models (made of plasticine and silicone mastic) to simulate the ductile deformation of rocks and diapirism
- Sandboxes, which are used to perform deformations (controlling for speed and constraints) to simulate brittle and brittle–ductile deformation of rocks, effects of basement structure and lithological heterogeneities, and pluton formation
- Work stations equipped with interactive screens and specialized software for geophysical data processing (Oasis Montaj™ and GM-SYS 2D extension, Geosoft), geotechnical 2D analysis (UDEC™5.0, Itasca), 3D reconstruction (GOCAD®, Gocad Research Group), and PIV imagery (StrainMaster, LaVision)

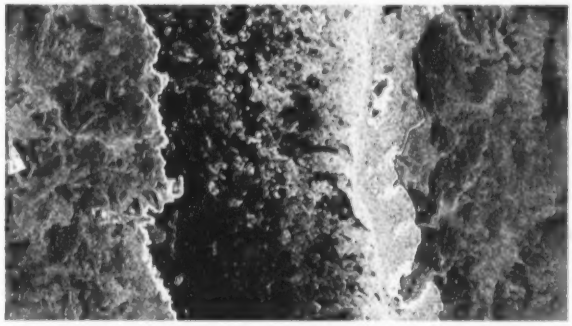
CONTACT:
Dr. **Lyal Harris**, lyal.harris@ete.inrs.ca

Applied remote sensing

Analysis of earth observation images to map and model different processes, particularly those related to water resources in northern environments

Satellite radar (RADARSAT, ASAR, TerraSAR-X) and optical (GeoEye, Quickbird, Ikonos, NOAA) imagery enables researchers to develop applications to measure and monitor water resources, the cryosphere (snow, ice, frozen soil), and wind resources. The Centre possesses several hundred images along with specialized software to process and analyse those images (Geomatica®, eCognition, ArcGIS, and MATLAB®).

Field measurements (with snow sampler, georadar, GPS and camera, weather stations, and moisture probes) are used to calibrate and validate the algorithms developed.



RADARSAT-2 image centred on Kuujjuaq harbour (© MDA and Canadian Space Agency)

CONTACTS:
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Dr. **Karem Chokmani**, karem.chokmani@ete.inrs.ca

Hydrological numerical models

Several hydrological modeling software programs have been developed by the Centre's researchers.

To assist river hydraulic studies

H2D2/MODELEUR: H2D2 is a finite-element software program that is modular and extendable. It is used to solve the shallow water equations, also known as St. Venant, advection-diffusion with different kinetics and bottom sediment transport. It can be used coupled to MODELEUR, a specialized geographic information system (GIS) for applications in river hydraulics.
www.gre-elm.ete.inrs.ca/H2D2

To assist surface water management at the watershed scale

HYDROTEL/PHYSITEL: HYDROTEL is a distributed hydrological model combining remote sensing and GIS data. This model can simulate a whole set of hydrological processes such as inflows to hydroelectric reservoirs, maximum flood levels (for dam safety), the role of wetlands and land-use planning within the hydrological cycle of watersheds. PHYSITEL, a specialized GIS, enables database formatting for various distributed hydrological models.
http://urlin.rs/hydrotel

GIBSI: Integrated modeling and data management software program for watersheds that includes a database management system and a GIS. It supports decision-making by enabling water managers to explore different resource and land use strategies at the watershed scale (e.g., assessment of beneficial management practices in agriculture; evaluation of contamination risks for drinking water sources).
http://urlin.rs/gibsi

CONTACTS:
H2D2: Dr. **Yves Secretan**, yves.secretan@ete.inrs.ca
HYDROTEL & GIBSI: Dr. **Alain N. Rousseau**, alain.rousseau@ete.inrs.ca

LABORATORIES FOR SCIENTIFIC AND TECHNOLOGICAL INNOVATION IN ENVIRONMENT

These laboratories host the larger research equipment not compatible with conventional laboratories, and applied research pilot units that require a more robust work environment.

Environmental hydraulics

Simulation of waves, tides, and strong river currents in a large-scale flume to develop sustainable approaches of shoreline management

This multifunctional large-scale flume is the fourth largest, and by far the most versatile, facility of its kind in the world. Simulations can be done at scales from 1:5 to 1:1 depending on processes.

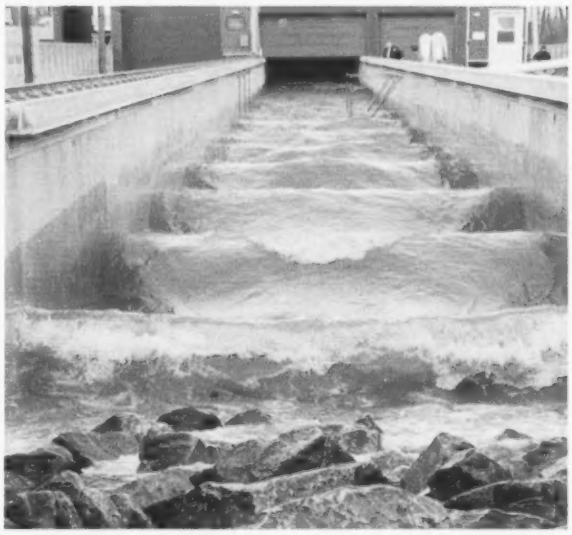
Potential applications are numerous. It can used for example to

- Model the stability profile of beaches
- Model sedimentation in ports and marinas
- Study the interaction between waves and currents on coastal and offshore structures
- Model wave runup and overtopping on coastal structures caused by sea level rise
- Simulate tidal effects on port structures
- Simulate ice effects on shorelines in the presence of waves and currents
- Model pollutant dispersal and transport in complex hydraulic systems
- Design shore protection infrastructure and scheme

The flume is **120 m long**, **5 m wide**, and **5 m deep**. It is equipped with a 10-t gantry crane and includes

- Wave maker to produce different types of waves
- Wave absorber (rock riprap)
- Water transfer system to a 3500-m^3 reservoir to simulate tides
- Bidirectional water circulation system to produce a 5 m^3/s flow generated by a thruster
- Series of 13 multipurpose supports for measuring instruments (flow rate, turbidity, topography, etc.) and 13 other supports for water level measuring instruments
- Data acquisition system with a capacity of more than 1600 sensors

Sedimentological analyses can be done on-site with a CT scanner (see next section) and small-scale flumes that can reproduce steady flows, waves, and gravity movements.



Large-scale flume (© Denis Bernier)

CONTACT:
Dr. **Bernard Long**, bernard.long@ete.inrs.ca

Computed tomography

Non-destructive measurements of density variations in solid bodies (internal structure, porosity, etc.) and of dynamic processes, mainly in hydrology

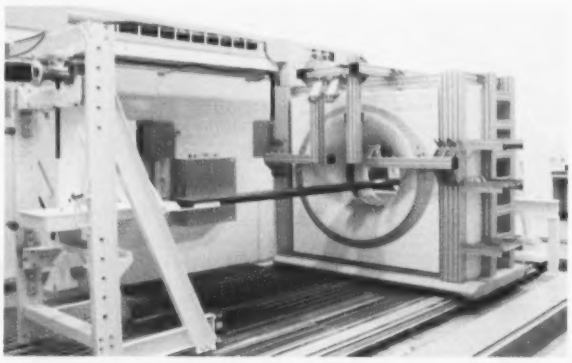
The Centre's computed tomography (CT) facility consists of a **Siemens SOMATOM Sensation 64** CT scanner, a data storage and treatment unit, a sedimentology laboratory, and equipment for hydraulic, biosedimentology, and hydrology experiments. This world-class infrastructure is unique in Canada.

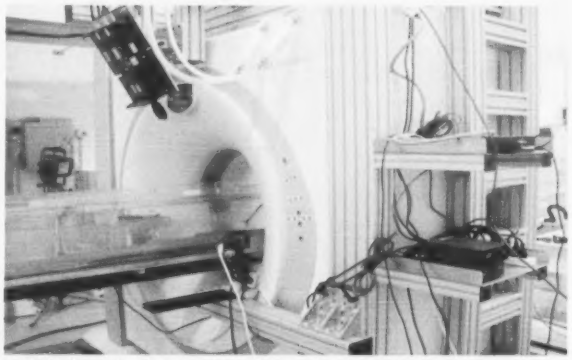
Modified from medical equipment, the scanner enables the 3D study of solid structures and liquid flows using a volume created from a series of simultaneous images with submillimetre resolution.

The equipment is configured to accommodate a wide range of applications. The scanner is sensitive to density variations of 0.1%. It has a 70-cm-diameter opening and a source/sensor configuration enabling 360° measurements around the analysed body. Finally, it is installed on 4-m-long rails, enabling the analysis of long objects such as tree trunks and sediment cores.

The facility also includes instruments such as a laser granulometer, aquariums and pressure compartments to measure bioturbation, and hydraulic mini-flumes to reproduce one-way currents, waves, and gravity movements. The mini-flumes come with instruments such as PIV, ADCP, and ADV current profilers, resistivity probes, OBS, and cameras. The large-scale flume (see previous section) can be used to scale up the measurements made with the mini-flumes.

This very precise equipment can be useful in a large variety of research fields, including marine engineering (measurement of sediment transport), geological engineering (geological risks and behaviour of gas hydrate), hydrogeology (fluid and contaminant migration), forestry (impacts of insect pests), dendrochronology (density variations in tree rings), palaeontology (detection of microfossils in sediment), marine ecology (benthic fauna behaviour), metallogeny (analysis of 3D structure of alloys), petrography (rock core analysis), and archaeology (analysis of internal structure of metallic artefacts).





SOMATOM Sensation CT scanner (with mini-flume in bottom image)

CONTACT:
Dr. **Bernard Long**, bernard.long@ete.inrs.ca

Bioprocesses

Development and optimization of biological transformation processes used to convert waste into value-added products

All steps of the conversion process can be carried out using modular units, including conditioning of the raw material, waste transformation, and recovery of the end product. The objective is to develop, optimize, and scale new bioprocesses and recover, purify, and characterize the various products obtained from fermentation.

Either waste (urban, industrial, and agricultural) or synthetic culture media can be used as substrate. The value-added products obtained can be microbial and fungal biopesticides, microbial inoculants, plant growth promoters, industrial enzymes, biopolymers, biofuels, biosurfactants, and biohydrogen.

Two hydrolyzers (of 150- and 2000-litre capacity) are used to prepare the substrates. The facility includes two instrumented fermentation laboratories, one reserved for waste and the other for synthetic media in order to avoid any contamination. Each fermentation laboratory has its own bioreactors (of 5-, 15-, 150-, and 2000-litre capacity).

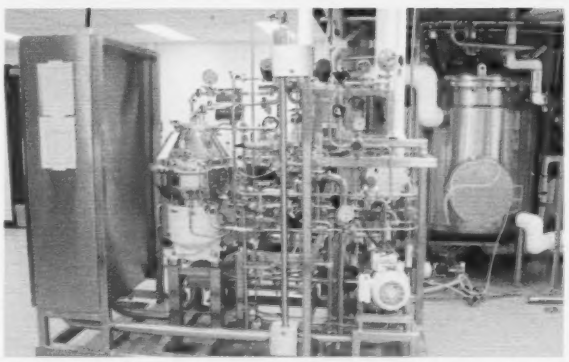
The final step, recovery of the end product, uses the following modules to treat the fermented broth:

- Continuous centrifuge
- Microfiltration and ultrafiltration unit
- Protein separation system using chromatography and ion exchange
- Spray dryer to obtain powder or granules
- Freeze dryer

The main analytical instruments used are

- Flow cytometer
- DNA thermal cycler
- Electrophoresis system

150- and 2000-litre capacity hydrolyzers



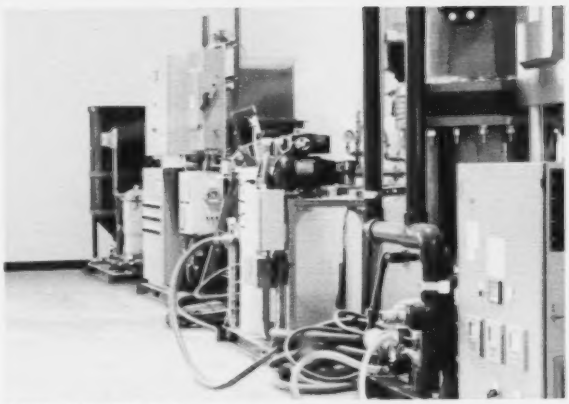
Continuous centrifuge

CONTACT:
Dr. **Rajeshwar Dayal Tyagi**, rd.tyagi@ete.inrs.ca

Environmental electrotechnologies

Development of electrolytic, membrane, and oxidative processes to optimize water and wastewater treatment

The objective of the LEEPO (Laboratory of environmental electrotechnologies and oxidative processes) is to develop innovative processes to improve existing water and industrial effluent treatment systems and replace conventional technologies that are ineffective at removing microbial, inorganic, and refractory organic contaminants. One specific objective is to design portable compact units with a large spectrum of decontamination capabilities.



LEEPO pilot-scale equipment

The main equipment includes

- Voltamperometric unit (galvanostat/potentiostat)
- Potentiometric titrator
- UV-vis and photoluminescence spectrophotometers
- Electrocatalysis and ozonation cells
- Sonochemical and photocatalytic reactors
- Two electrooxidation/electrodeposition laboratory type (2–5 L) and one pilot-scale (100–150 L) reactors
- Two electrocoagulation/electroflotation laboratory type and one pilot-scale reactors
- Laboratory type (4–6 L) and pilot-scale (100–150 L) membrane bioreactors
- Membrane units (microfiltration, ultrafiltration, nanofiltration, reverse osmosis)

Some of these modules can be installed in the mobile decontamination laboratory.

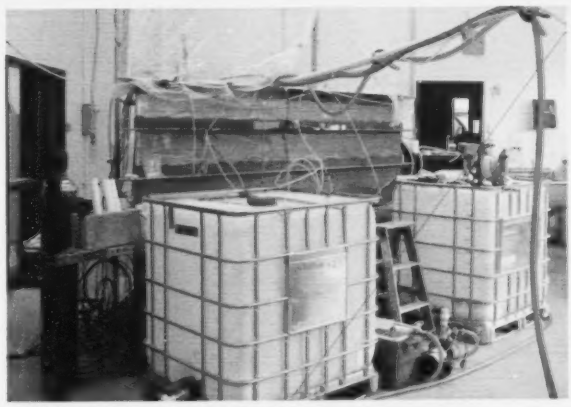
CONTACT:
Dr. **Patrick Drogui**, patrick.drogui@ete.inrs.ca

Soil and groundwater contamination

Study of soil and groundwater contaminant behaviour and development of *in situ* remediation technologies at a scale intermediate between the laboratory and the field

The following equipment is used to simulate groundwater flows, monitor contaminant transport, and test new decontamination technologies for soil and groundwater:

- Two reservoirs of 4 and 9 m^3 to test *in situ* remediation technologies by replicating injection/extraction patterns
- Mobile multiphase extraction and soil washing units equipped with monitoring instruments
- Columns used to study soil contaminant migration and test different passive treatment methods (natural attenuation, reaction wall)
- Columns of different volumes to test the performance of active treatment methods (air sparging, venting, biodegradation, soil washing with surfactants, and chemical oxidation)
- Laboratory that can be cooled to 6°C (groundwater temperature)



Multiphase extraction and soil washing test

- Measuring instruments to characterize sampled soils, water, and organic phases (granulometry, characteristic curve, density, viscosity, interfacial tension, contact angles)

CONTACT:
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MOBILE FACILITIES

These facilities are used to carry out on-site tests and analyses. In addition to the following facilities, a modified truck serves as a biogeochemistry laboratory to prepare and process field samples directly on-site before transport.

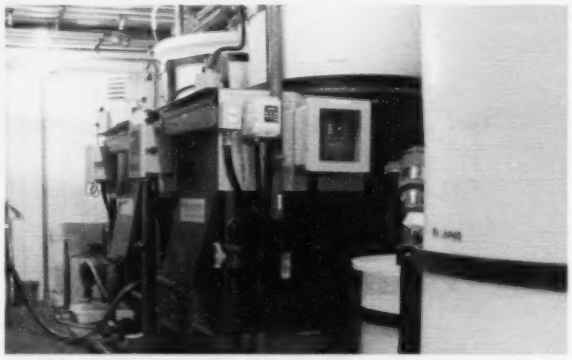
Decontamination

Pilot-scale implementation of environmental technologies using chemical, physical, and biological processes to optimize decontamination methods for liquid and solid residues

This mobile facility is used to test a whole set of decontamination technologies directly on the sites where the wastewater or contaminated soils are produced. The trailer can accommodate various treatment units that can be specifically assembled to meet different decontamination needs.

Mobile decontamination laboratory

Liquid residues that can be treated include contaminated groundwater and municipal, industrial, and agroalimentary wastewater. Decontamination processes for solid residues can apply to soil, industrial waste, hazardous material, and sewage sludge. Some experimental setups can address complex issues such as mixed contamination or contamination implying refractory pollutants.



Lamellar clarifiers with instrumentation

The main modular units are

For liquid residues

- Lamellar clarifier
- Bioflotation/biofiltration/sequential batch reactor
- Filter press
- Tray filter
- Centrifuge
- Rotary ring press
- Ion exchanger
- Adsorption column

For solid residues

- Screening unit
- Magnetic separator
- Shaking table
- Fluidized bed
- Flotation cells

CONTACTS:
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Dr. **Guy Mercier**, guy.mercier@ete.inrs.ca

Aquifer characterization

Development of detailed field characterization techniques for aquifers to assist numerical modeling

The main equipment used to characterize the physical and geochemical properties of aquifers is a Geotech 605 drilling and sounding rig. Data collected with this equipment enable researchers to model flows and contaminant transport within aquifers. Researchers are also able to evaluate aquifer sensitivity to contamination and determine the most appropriate protection and exploitation strategies for sustainable management of the groundwater resource.

GEORIG 605 in the field

This crawler-mounted rig can simultaneously record several data parameters, enabling the identification of materials and determination of their mechanical and electrical responses and porosity. It can be used for soil or groundwater sampling, eliminating the need for permanent observation wells. The system can also be used to install observation wells by penetration (without drilling). One of the spindles can be used to make soundings by cone penetration (CPT) up to 30 m deep in loose sediments, and the other is equipped with a pneumatic drill to make soundings by rotary percussion up to 50 m deep in rocks and in sediments.

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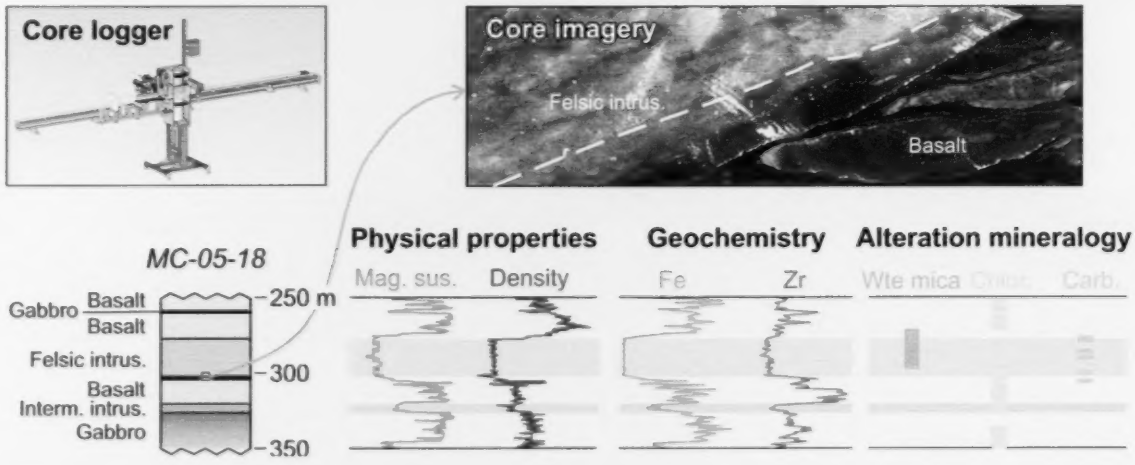
Characterization of rocks

High-resolution non-destructive measurements of physical, mineralogical, and chemical properties on drill cores

The LAMROC (Mobile laboratory of physical, mineralogical, and chemical properties of rocks) semi-automated system enables simultaneous measurements of several parameters (density, magnetic susceptibility, geochemistry, and mineralogy) on diamond drill cores. A line-scan image can also be acquired. The system is installed in a mobile trailer in order to obtain as much information as possible from drill cores directly on the storage site.



Several portable instruments are also available to measure the physical properties of rocks in the field (magnetic susceptibility, density, electrical conductivity, gamma radiation).

CONTACT:
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Research and teaching

Research teams

Jean-Christian Auclair (P) Limnology and geochemistry

Yves Bégin (P) Dendroecology
- Thibault Labarre (At and *MSc*)
- Mathilde Renaud (At)
- Sandy Erni (PhD)
- Nanie Ayotte (MSc)
- Yves Bouthilier (MSc)
- *Pierre-Paul Dion (I)*

Mario Bergeron (P) Inorganic and environmental chemistry
- *Alain Langlais (O)*

Normand E. Bergeron (P) Fluvial geomorphology and habitat
- *Joëlle Bédard (T)*
- Francis Bérubé (T)
- Clément Clerc (At)
- Flavien Pichon (At)
- Marc-André Pouliot (At)
- Mehdi Mekni (Postdoc)
- Stephen Dugdale (PhD)
- Elsa Goerig (PhD)
- Carol-Anne Gillis (PhD)
- *Patricia Johnston (PhD)*
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- *Maxime Grenier (MSc)*
- *Pascal Marcotte (I)*
- *Magaly Oakes (I)*
- *Gabrielle Préfontaine-Dastous (I)*
- André Boivin (Field station supervisor)

Monique Bernier (P) Remote sensing
- Yves Gauthier (O)
- Jimmy Poulin (O)
- Clément Clerc (At)
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- Maria Dissanska (PhD)
- Yannick Duguay (PhD)
- Rebecca Filion (PhD)
- Charles Gignac (PhD)
- Kim Huong Hoang (PhD)
- Parvin Kalantari (PhD)
- Marion Tanguy (PhD)
- *Thomas Bergeron (MSc)*
- Stéphanie Bleau (MSc)
- Stéphane De Munck (MSc)
- *Karine Labrecque (MSc)*
- Laurence Provencher-Nolet (MSc)
- Tahiana Solonjatovo Ratsimbazafy (MSc)
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- Nicolas Reynier (PhD)
- Sabrine Metahni (MSc)
- *Loïc Bovio (I)*
- *Mel Constant (I)*
- *Mathilde Derouet (I)*
- *Pascal Manizan (I)*
- *Vincent Métro (I)*
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- Heldiane Souza Dos Santos (I)

Satinder Kaur Brar (P) Bioconversion and emerging contaminants
- Gurpreet Singh Dhillon (PhD)
- Fatma Gassara (PhD)
- Dipti Prakash Mohapatra (PhD)
- Saurabh Jyoti Sarma (PhD)
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- *Surinder Kaur (I)*

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- Bérénice Bougas (Postdoc)
- Paula Sanchez-Marin (Postdoc)
- Kristin Mueller (PhD)
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- Yiping Han (At)
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- Alexandre Lekina (Postdoc)
- Roland Pierre Ngom (Postdoc)
- Mohamed Aymen Ben Aissia (PhD)
- Mohamed Ali Ben Alaya (PhD)
- Yohann Moanahere Chiu (PhD)
- Martin Durocher (PhD)
- Reza Modarres (PhD)
- Hussein Wazneh (PhD)
- Bouchra Nasri (MSc)
- Dhouha Ouali (MSc)

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- *Mariem Fadhlaoui (I)*
- *Maxime Gérin-Ouellet (I)*

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- Karista Hudelson (PhD)

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- Mandé Léa Rosine Guitaya (PhD)
- Brahima Seyhi (PhD)
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- *Jennifer Tardif (I)*

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- Babacar Toumbou (Postdoc)
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- Hind El-Housni (MSc)
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- Jihène Zaiem (MSc)

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- Jacqueline Levy (Postdoc)
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- Michel Lavoie (PhD)
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- Roland Pierre Ngom (Postdoc)
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- Roger Levasseur (MSc)

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- Caroline Sévigny (PhD)
- Jessy Barrette (MSc)

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- Isabelle Proulx (PhD)
- Maikel Rosabal Rodriguez (PhD)
- Karine Bertrand (MSc)
- *Julien Lacharité (MSc)*

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Lyal Harris (P) Structural geology and geophysics
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Camille Armengaud (MSc)

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Marc-André Carrier (O)
Harold Vigneault (O)
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Patrick Brunet (MSc)
Pierre Ladevèze (MSc)
Emmanuelle Millet (MSc)
Morgan Peel (MSc)
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David Collins-Fekete (I)
Pierre-Luc Rousseau (I)
Baptiste Tonon (I)

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Guillaume Talbot (At)
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Laurène Autixier (I)
Ian Beauregard (I)
Marc-André Guérard (I)
Ariane Lévesque (I)
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Jean-Philibert Moutenet (O)
Harold Vigneault (O)
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Elena Konstantinovskaya (As)
Franck Diedro (Postdoc)
Sébastien Lange (Postdoc)
Jasmin Raymond (Postdoc)
Tien Dung Tran Ngoc (Postdoc)
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Martin Racine (Field assistant)
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Linda Aubert (Secretary)

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Richard Lévesque (T)
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Luc Trépanier (O)
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Jean-Philippe Drolet (PhD and *MSc*)
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Guy Mercier (P) Decontamination and reclamation
- Emmanuelle Cecchi (As)
- Lan Huong Tran (As)
- *Pauline Riche (At)*
- Sara Bisone (PhD)
- Dileep Palakkeel Veetil (PhD)
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- Christian Charron (O)
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- *Byungsoo Kim (Postdoc)*
- Alexandre Lekina (Postdoc)
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- Dorra Hammami (MSc)
- Iris Klein (MSc)

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- *Gaëtan Gatien (Field assistant)*
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- Julie Anaïs Debreil (PhD)
- Séverine Delpit (PhD)
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- *Abhidheya Dasi Holfeld (MSc)*
- *Thierry Plamondon-Tremblay (I)*

Alain N. Rousseau (P) Hydrological modeling
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- Alain Royer (T)
- Sébastien Tremblay (T)
- Stéphane Savary (O)
- *Patrick Gagnon (As and PhD)*
- *Sylvio Jose Gumiere (Postdoc)*
- Dennis Hallema (Postdoc)
- Daniel Nadeau (Postdoc)
- Gwenael Carrer (PhD)
- Maxime Fossé (PhD)
- Mushombe Muma (PhD)
- Imene Ben Nasr (MSc)
- Gabriel Hould Gosselin (MSc)
- *Philippe Noël (MSc)*
- Mathieu Oreiller (MSc)
- Claudie Ratté-Fortin (MSc and *I*)
- Léon Cantin (I)
- *Frédéric Horth Whittom (I)*
- *Pierre-Érik Isabelle (I)*
- Jean-Christophe Leclerc-Massé (I)

Yves Secretan (P) Numerical hydrology
- Jimmy Poulin (O)
- Pascale Matte (PhD)
- *Pierre-Yves Lapointe (I)*
- *Benoit Maranda (I)*
- *Guillaume Martel-Genest (I)*

André St-Hilaire (P) Environmental and statistical hydrology
- Anik Daigle (As)
- Sandra Proulx-McInnis (At)
- *Carol Rendell (At)*
- *Dae Il Jeong (Postdoc)*
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- Laurie Beaupré (MSc)
- *Mohammed Aziz Es Salhi (MSc)*
- *Hélène Higgins (MSc)*
- Sébastien Ouellet-Proulx (MSc and *I*)
- Christian Saad (MSc)
- *Simon Massé (I)*
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Normand Tassé (P) Geochemistry

Rajeshwar Dayal Tyagi (P) Waste bioconversion
- Jyothi Bezawada (As)
- Jean-Robert Gnepe (As and *PhD*)
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- Mathieu Drouin (PhD)
- Lalit Lalit Kumar (PhD)
- Sarra Magdouli (PhD)
- Amine Mahmoudi (PhD)
- Josée-Anne Majeau (PhD)

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Tanaji More (PhD)
Sridhar Pili (PhD)
Tarek Rouissi (PhD)
Manju Shahare (PhD)
Jay Shankar Singh Yadav (PhD)
Xiao Lei Zhang (PhD)
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Syrine Gargouri (I)
Titouan Genty (I)

Jean-Pierre Villeneuve (P) Integrated management of water resources

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Babacar Tourmbou (Postdoc)
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Phu Duc Nguyen (PhD)
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Kassandra Bouchard (I)
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Julie Fortin (Secretary)

Other students

Earth Science students supervised by associate professors
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Antoine Caté (PhD, Patrick Mercier-Langevin)
Anthony-Franco De Toni (MSc, Louise Corriveau)
Lauriane Dinis (PhD, Martine M. Savard)
Annick Doucet (PhD, Martine M. Savard)
Vivien Janvier (PhD, Sébastien Castonguay)
Josué Jautzy (PhD, Jason Ahad)
Lise Lamarche (PhD, Michel Parent)
François Leclerc (PhD, Jean H. Bédard)
Jean-François Montreuil (PhD, Louise Corriveau)
Maud Naulier (PhD, Martine M. Savard)
William Oswald (PhD, Sébastien Castonguay)
Marie-Amélie Pétré (PhD, Alfonso Rivera)
Jean-François Ravenelle (PhD, Benoît Dubé)
Rachel Thériault (MSc, Martine M. Savard)
David Yergeau (PhD, Patrick Mercier-Langevin)

Enrolled in the Professional Master's Program
Maxime Bélanger
Steve Boivin
Raphaël Combes
Gabriel Cotte
Charles-Olivier Laporte
Sanae Outoun
Léonie Sévigny-Côté
Magali Wirtensohn

Other graduate students
Thomas-Charles Fortier-Filion (MSc supervised by Anne-Catherine Favre)
Elodie Laforgue (non-degree status)

Other professors

Emeritous

Bernard Bobée
Georges Drapeau
Michel Slivitzky

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Bernard Vigneault, GSC-Quebec

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Invited

Marc Amyot, Université de Montréal
Simon Barbabé, UQTR
Hamel Benmoussa, Centre de recherche industrielle du Québec (CRIQ)
Louis Bernatchez, Université Laval
Thomas Buffin-Bélanger, UQAR
Daniel Caissie, Fisheries and Oceans Canada
Michel Chouteau, École Polytechnique de Montréal
Paul Cooper, University of Toronto
Daniel Cossa, Institut français de recherche pour l'exploitation de la mer (IFREMER, France)
Simon Charles Courtenay, Fisheries and Oceans Canada
Richard A. Cunjak, Canadian Rivers Institute, University of New-Brunswick
Jean-Pierre Dedieu, LARHRA - CNRS (France)
Nassir El-Jabi, University of Moncton
Anne-Catherine Favre, Université Laval
Jaime M. Gárfias Soliz, Centro Interamericano de Recursos del Agua (CIRA, Mexico)
Pierre-Louis Gosselin, Institut national de la santé publique du Québec (INSPQ)
Sylvio Jose Gumiere, Université Laval
Katy Haralampides, University of New-Brunswick
Klaus Holliger, Université de Lausanne (Switzerland)
Eric Johnson, Hartwick College (New York, USA)
Sylvain Jutras, Université Laval
Sandra Kentish, University of Melbourne (Australia)
Scott Lamoureux, Queen's University
Véronique Lapaige, Université de Montréal
Isabelle Larocque Tobler, University of Bern (Switzerland)
Robie W. Macdonald, Fisheries and Oceans Canada
Jean-Louis Morel, Institut national polytechnique de Lorraine (INPL, France)
Mir Abolfazo Mostafovi, Université Laval
Michel Nolin, Agriculture and Agri-Food Canada
Reinhard Pienitz, Université Laval
John F. V. Riva, retired, Université Laval
Marie-Odile Simonnot, Institut national polytechnique de Lorraine (INPL, France)
Minh Y Tran, Vietnam Academy of Science and Technology (Vietnam)
Bruno Tremblay, McGill University
Gozo Tsujimoto, Kobe City College of Technology (Japan)
José R. Valéro, retired, Canadian Forest Service
Kevin J. Wilkinson, Université de Montréal
Fumihiko Yamada, Kumamoto University (Japan)
Fatiha Zidane, Université Hassan II (Morocco)

Lecturers

Louis Fontaine (Course EAU 301)
Yvon Maranda (Course EAU 203)

Invited researchers

Gilles Bellefleur, Geological Survey of Canada (GSC)
Rudolf Bertrand, retired, INRS–Centre Eau Terre Environnement
Gerardo Buelna, Centre de recherche industrielle du Québec (CRIQ)
Athyna Cambouris, Agriculture and Agri-Food Canada
François Caron, Centre interuniversitaire de recherche sur le saumon de l'Atlantique (CIRSA)
Daniel Caya, Ouranos Consortium
Marie Clément, Fisheries and Oceans Canada
Catherine Couillard, Fisheries and Oceans Canada
Emmanuela Diaz, Defence Research and Development Canada, Valcartier (DRDC Valcartier)
Bernard Doyon, Collège F.X. Garneau
Sylvie Dufour, CNRS (France)
Peter I. Galbraith, Fisheries and Oceans Canada
David Huard, Ouranos Consortium
Feten Jarraya Horriche, Centre de recherches et des technologies des eaux (Tunisia)
Mickaële Le Ravalec-Dupin, IFPEN (France)
Yvon Maranda, Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, Quebec
Emma Michaud, CNRS (France)
Marc Mingelbier, Ministère des Ressources naturelles, Quebec
Marie Minville, Institut de recherche d'Hydro-Québec (IREQ)
Luc Perreault, Institut de recherche d'Hydro-Québec (IREQ)
Louis Prieur, Observatoire océanologique de Villefranche-sur-Mer (France)
Milla Rautio, UQAC
Rao Y. Surampalli, United States Environmental Protection Agency (EPA, USA)
Muriel Thibaut, IFPEN (France)
Richard Turcotte, Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, Quebec
Marc Vallée, Fugro Airborne Surveys

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- Luc Rose
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- Jean-Michel Thériault

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- Pauline Fournier
- Philippe Girard
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- Marie Létourneau
- Julie Perreault
- Lise Rancourt
- René Rodrigue

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Suzanne Dussault
- Johanne Desrosiers

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Anne-Marie B.-Martel (laboratories)
Stéphanie Geay (documentation)
Louis Noreau (laboratories)
Mathieu Robitaille-Boutin (administration)

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